openreach

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Suppliers' Information Note

For The Openreach Network

Generic Ethernet Access G.fast (GEA-G.fast)

Service and Interface Description

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1. Service Outline

1.1 General

Openreach will provide a G.fast product variant, part of Openreach's Generic Ethernet Access (GEA) portfolio, over a combination of fibre and existing copper based infrastructure utilising G.fast technology, from here on referred to as GEA-G.fast.

This Suppliers' Information Note (SIN) provides details for Communications Providers (CPs) regarding connectivity and interfaces for the G.fast technology.

Two product variants are detailed that differ in their interface presentation at the End User premises (User to Network Interface, or UNI). The first variant is an Openreach supplied and maintained G.fast modem. The second variant is a CP supplied and maintained G.fast modem.

This SIN also provides details of the tests required to demonstrate compliance of a CP provided modem to the various technical and operational requirements.

It should be noted that the information contained within this SIN is subject to change due to Openreach developments, changes in global industry standards or due to feedback from customers, including CPs. Please check with the Openreach SIN site to ensure you have the latest version of this document.

In the event of a discrepancy between this document and referenced documents, this document takes precedence.

Further information regarding the product can be obtained by contacting your Openreach Sales and Relationship Manager.

1.2 High Level Architecture

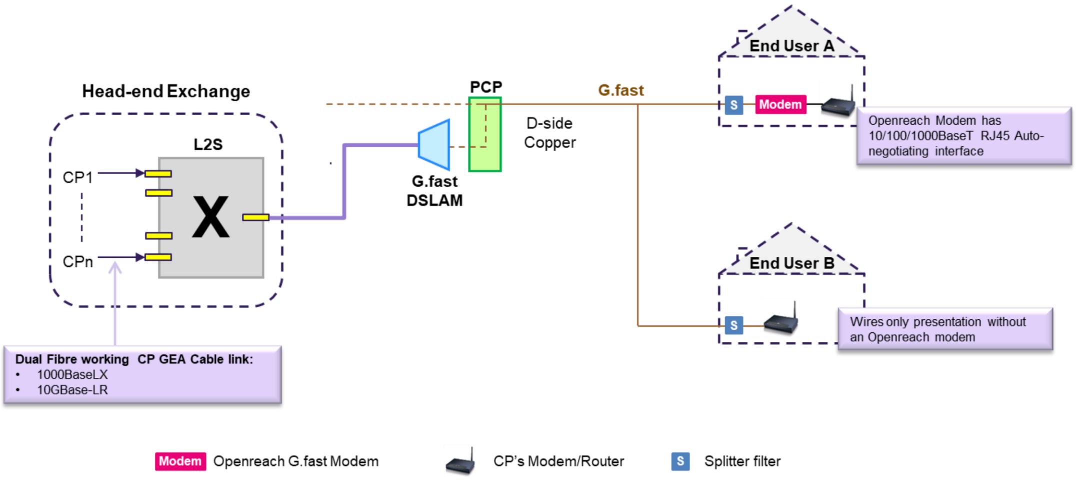

Head-end Exchange
L2S
CP1
CPn
X
Dual Fibre working CP GEA Cable link:
• 1000BaseLX
• 10GBase-LR
G.fast
DSLAM
PCP
D-side
Copper
G.fast
End User A
S
Modem
Openreach Modem has 10/100/1000BaseT RJ45 Auto-negotiating interface
End User B
S
Wires only presentation without an Openreach modem
Modem
Openreach G.fast Modem
CP's Modem/Router
S
Splitter filter

Figure 1 : High level architecture

Openreach will provide GEA-G.fast as an 'always on' Virtual LAN (VLAN) between a dedicated Layer 2 Switch (L2S) in the exchange and the end-user premises.

The GEA-G.fast service delivered will use a copper connection between the Digital Subscriber Line Access Multiplexer (DSLAM) and the customer's premises.

At the Point of Handover, the GEA-G.fast service will be delivered to the CP via a GEA Cablelink product. The GEA Cablelink will transport multiple GEA services from the same L2S to a location within the same Point of Handover specified by the CP. These Cablelinks may carry GEA-G.fast, GEA-FTTC and GEA-FTTP services.

The VLAN will be able to carry data communication signals after the CP has registered for service activation for their end-user.

1.2.1 G.fast Rates

The GEA-G.fast product will offer the following Ethernet product rates when delivered using G.fast:

Product 1

- A peak downstream (from CP to end-user) rate of up to 330 Mbit/s.
- A downstream prioritised rate of 110 Mbit/s.
- An upstream (from end-user to CP) rate of up to 50 Mbit/s.

Product 2

- A peak downstream rate of up to 160 Mbit/s.
- A downstream prioritised rate of 110 Mbit/s.
- An upstream rate of up to 30 Mbit/s.

CPs should also be aware of the following:

- There will be occasional internal Openreach management traffic on the G.fast line due to management activities. This traffic will take priority over user traffic but the impact will be negligible.
- There will be occasional firmware upgrades which will involve reasonable volumes of traffic (MBytes). Openreach will report to CPs when these are scheduled across the GEA-G.fast network.

1.2.2 G.fast Noise Margins

Currently the default target signal-to-noise ratio margin is set to 3dB in both the upstream and the downstream directions. The actual value shall be determined by the Dynamic Line Management (DLM) algorithm based on line stability and can vary between 3 and 28dB (in 1 dB steps). The upstream and downstream margin settings are independent of each other.

Lines may also have higher margins when they are at the rate cap for the product.

1.2.3 Rate Reporting

Rates will be reported via PPPoE intermediate agent insertion or DHCP option 82 0. These will need to be interpreted by the CP in order to allow payload traffic to be transmitted optimally.

The upstream and downstream G.fast data rate is reported to the CP upon PPP/DHCP discovery. The data rate states the upper rate at which Ethernet traffic can be transmitted on the link. This traffic comprises of:

- A 4 byte per frame overhead added by Openreach for internal routing
- A degree of overhead introduced by G.fast Packet Transfer Mode (PTM) layer
- The end-user traffic sent from the CP, or from the end-user

As a result of these overheads, the actual achievable throughput in bits per second is dependent on the line rate and frame size of the data being transmitted. Openreach advise CPs to consider carefully how they interpret the reported rates in relation to the services they sell, the specifics on an individual end-user's use of the service, and any impacts of their own network.

If GEA-G.fast Multicast is used (which does not transit the same equipment (e.g. BRAS)), the CP will need to take account of this traffic on the end-user’s line.

Note: the line rate may change due to seamless rate adaptation (SRA) and fast rate adaptation (FRA) events without the rate reporting being updated (see Section 2.1.6).

1.3 GEA-G.fast Cablelink

The GEA-G.fast Cablelink product will be offered to the CP to order for connectivity to the L2S in the same Point of Handover building.

This will comprise:

- Either a 1 Gbit/s or a 10 Gbit/s Ethernet port into the L2S, 1000Base-LX (Single Mode only) for 1 Gbit/s and 10GBase-LR (Single Mode only) for 10 Gbit/s.
- Fibre connection from the port on the L2S to the location within the same Point of Handover specified by the CP.

CPs will need to specify the location of their equipment/presence to which the connection should be made as part of the order journey for each GEA-G.fast service ordered.

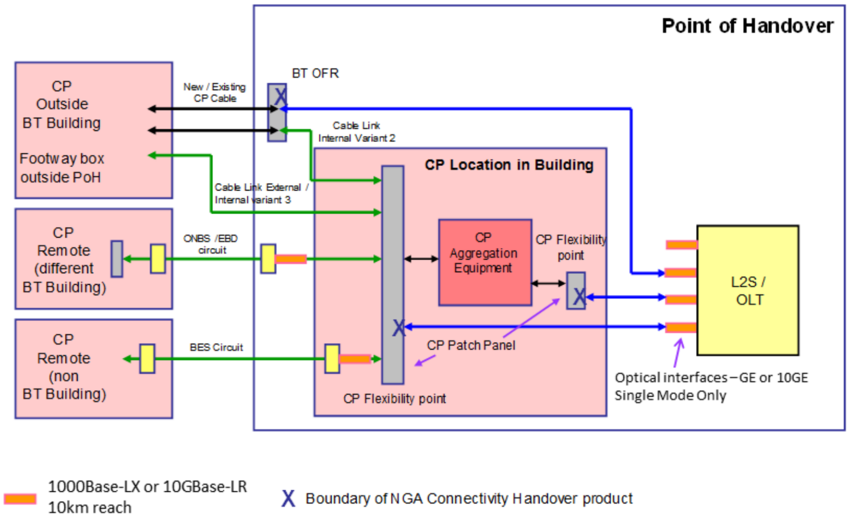

Point of Handover
BT OFR
CP Outside BT Building
Footway box outside PoH
New / Existing CP Cable
Cable Link Internal Variant 2
Cable Link External / Internal variant 3
CP Location in Building
CP Remote (different BT Building)
ONBS /EBD circuit
CP Aggregation Equipment
CP Flexibility point
L2S / OLT
CP Remote (non BT Building)
BES Circuit
CP Patch Panel
CP Flexibility point
Optical interfaces – GE or 10GE Single Mode Only
1000Base-LX or 10GBase-LR 10km reach
X Boundary of NGA Connectivity Handover product

Figure 2 : GEA-G.fast Head End Handover Connectivity

1.4 G.fast Physical Layer

The G.fast physical layer will comply with the mandatory requirements of ITU-T Recommendations G.9700 0 and G.9701 0 and their amendments and corrigenda. The following feature set will be implemented:

Feature	Status
Spectrum compatibility with VDSL2	Enabled
Vectoring	Enabled
Retransmission	Enabled
Seamless Rate Adaptation (SRA)	Enabled
Fast Rate Adaptation (FRA)	Enabled
Headline Line Rates (Product 1)	DS: 330 Mbit/s, US: 50 Mbit/s
Headline Line Rates (Product 2)	DS: 160 Mbit/s, US: 30 Mbit/s
Ability to implement RF notching if required	Enabled

Changes to MinETR EoC (Corrigenda 3)	Enabled
Support of Profile 106b	Enabled

Table 1 : G.fast Physical Transmission Layer Features

2. Interface Descriptions

The following sections define the interface descriptions for the various components used in GEA-G.fast.

2.1 GEA Cablelink

2.1.1 Physical connection

The identified interface option and location for the GEA Cablelink will need to be specified by the CP, either:

- CP owned and provided Interface Panel, or
- CP owned and provided equipment interface (Ethernet port).

The interface is the connector on the end of the Openreach fibre tail.

Only the following physical optical interface connector types are supported for connection to the CP provided identified interface:

- FC/PC
- LC
- SC

Note – Angled connectors are NOT supported.

The physical interface must be specified on the order request. Any conversion of interfaces is the CP's responsibility, i.e. the CP must provide interface converters on its card or at the interface panel, if necessary. Openreach engineers must be provided with access to the identified interface point (whether that is an interface panel or the CP's actual interface card itself) for both fulfilment and assurance purposes.

1 Gbit/s and 10 Gbit/s Single-Mode interfaces are described in SIN 360.

More information about the GEA Cablelink product can be found in the GEA Cablelink Product Description on the Openreach Portal (see http://www.openreach.co.uk).

2.1.2 Ethernet Frame Size

The maximum supported Ethernet frame size is 1530 bytes (excluding IFG and pre-amble and single/double tag – see 2.1.3).

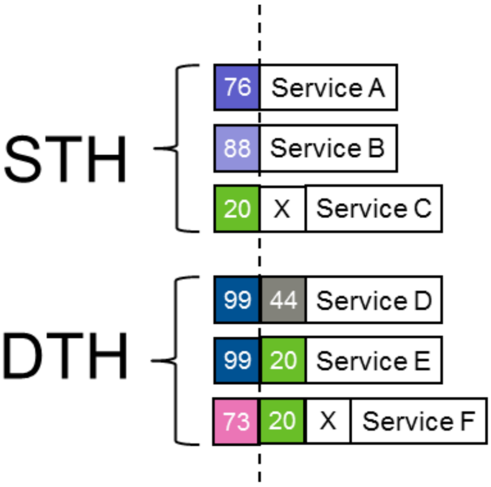
2.1.3 VLAN Tagging Options at the GEA Cablelink

2.1.3.1 Openreach added tags

On the GEA Cablelink, all traffic will be presented using single tagging or double tagging on a per VLAN basis. Both options can be used on the same GEA Cablelink on a per GEA order basis. The tagging option to use for a specific GEA order is explicitly selected by the CP when ordering.

The VLAN used for end-user traffic is referred to as a Customer VLAN or "C-VLAN".

A CP may optionally choose to use an additional level of VLAN tagging so that C-VLANs can be grouped within another VLAN, referred to as a Service VLAN or "S-VLAN". Figure 3 shows how numbering is aligned between Single and Double tagged handover.



Note X represents any CP added VLAN tags

Figure 3 : GEA Cablelink VLAN tagging numbering alignment

- Single Tagged Handover (STH)
    - The Outer VLAN is the C-VLAN.
    - The Outer VLAN will carry the end-user traffic and will have a tag in the range 2 to 3000 or 3071 to 4094[*]. Openreach will allocate the lowest available unused tag.
- Double Tagged Handover (DTH)
    - The Outer VLAN is the S-VLAN, and the Inner VLAN is the C-VLAN.
    - Outer VLAN tag(s) must be ordered via the Lead to Cash Modify process against a GEA Cablelink (GEA Cablelink provision must be complete) before they can be used in a GEA order.
        - The Outer VLAN will have a tag in the range 2 to 3000 or 3071 to 4094.

---

[*] *Please note - values between 3001 and 3070 are reserved for GEA Multicast.*

  - Where double tagging is required the CP must include the Outer VLAN tag value in the GEA order.
    - Openreach will allocate the lowest available unused tag if the CP does not specify the tag.
  - The Inner VLAN will carry the end-user traffic and will have a tag in the range 2 to 4094. Openreach will allocate the lowest available unused tag.

Although the VLAN ranges above exceed the maximum number of connections supported on a GE Cablelink, the CP shall permit any value within the stated ranges to be used.

2.1.3.2 CP added tags

The following is true for Openreach provided NTE (see also Figure 3):

- CPs can optionally add tags in the downstream direction (commonly referred to as X-tags) and these will be transported transparently through to the UNI of the Openreach modem.
- End-user CPE such as set top boxes (STB) and PCs may add X-tags in the upstream direction, and these will be transported transparently through to the CP. An exception to this is tag 0 which will be removed by Openreach (see section 2.1.5.2 for more detail).

2.1.4 Ethertype

The CP can specify whether the Outermost VLAN Ethertype on the Cablelink will be set to 0x81-00 or 0x88-A8. This applies to the GEACablelink as a whole and irrespective of single or double tagging of the GEA-G.fast services carried.

2.1.5 Quality of Service (QoS)

2.1.5.1 Downstream

Figure 4 outlines the downstream QoS for GEA-G.fast.

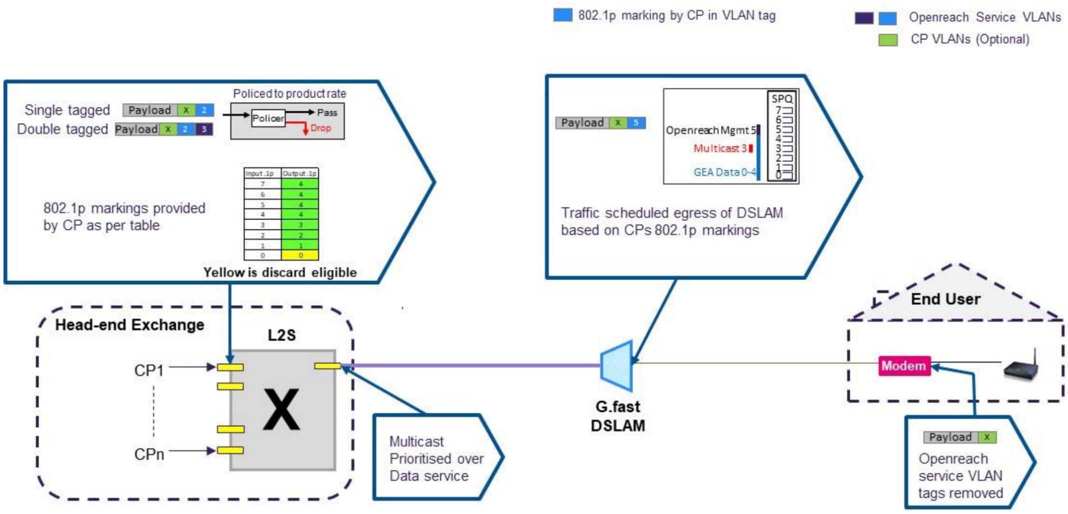

802.1p marking by CP in VLAN tag
Openreach Service VLANs
CP VLANs (Optional)
Single tagged
Payload X 2
Double tagged
Payload X 2 3
Policed to product rate
Policer
Pass
Drop
802.1p markings provided by CP as per table
Input .1p
Output .1p
7 4
6 4
5 4
4 4
3 3
2 2
1 1
0 0
Yellow is discard eligible
Head-end Exchange
L2S
CP1
CPn
X
Multicast Prioritised over Data service
Payload X 5
Openreach Mgmt 5
Multicast 3
GEA Data 0-4
SPQ
7
6
5
4
3
2
1
0
Traffic scheduled egress of DSLAM based on CPs 802.1p markings
G.fast DSLAM
End User
Modem
Payload X
Openreach service VLAN tags removed

Figure 4 : Downstream QoS

CPs can use the C-VLAN Priority as per IEEE 802.1p on downstream GEA-G.fast traffic. For G.fast, 802.1p values 0, 1, 2, 3, and 4 are supported. 802.1p values 5, 6 and 7 are not supported and will be re-marked to 4.

GEA-G.fast will make use of these markings in two ways:

- Scheduling traffic from the L2S/DSLAM to the NTE; and
- In the event of congestion within the Openreach network, the markings will be used to identify which frames can be dropped first for a particular end-user.

802.1p traffic marking is optional but strongly recommended to ensure traffic is scheduled according to CP requirements.

Frames with higher markings are delivered first using strict priority. Note that downstream GEA Multicast, which has an 802.1p value of 3, converges with GEA-G.fast Data at the DSLAM port. It is therefore possible to prioritise selected GEA-G.fast Data traffic above Multicast (but only at the DSLAM G.fast port) by sending GEA-G.fast Data with a 802.1p value of 4. CPs should be aware this could impact the Multicast service for the end-user receiving high rates of priority 4 GEA-G.fast data traffic.

2.1.5.1.1 Per end-user/ Intra end-user frame drop prioritisation

The C-VLAN PCP markings are used to identify the order in which traffic can be dropped.

- For G.fast, 802.1p = '4,3,2,1' = "Should Not Drop"
  (no drop priority differentiation between these 4 markings until the egress DSLAM G.fast port)
- 802.1p = '0' = "Can Drop"

Where Double Tagging is used, the markings must be applied to the Inner C-VLAN.

The 802.1p priority field allows the CP to influence which frames are dropped first under congestion, thus allowing loss sensitive applications to have greater protection and at the same time allow best-efforts applications to benefit from full network capacity when it is available, but at the risk of frame loss. Openreach will promote or demote traffic based on the prioritised rate to ensure each end-user has fair access to the available network capacity as described below. It should be noted that the PCP markings in the traffic will not be altered during promotion or demotion.

- When an end-user's "Should not drop" marked traffic is supplied below the prioritised rate, then some or all of that end-users "Can drop" frames will be arbitrarily promoted to "Should not drop" so that, if possible, the "Should not drop" traffic rate equals the prioritised rate.
- Where an end-user's traffic is marked "Should not drop" and exceeds the prioritised rate, then some of that end-user's frames will be arbitrarily demoted to "Can drop" so that the rate of "Should not drop" traffic equals the prioritised rate.

Therefore, for optimal performance the CP should ensure loss-sensitive traffic is marked "Should not drop" and kept within the prioritised rate of the end-user's service. Where the line rate is below the service prioritised rate, the CP should also note Section 2.1.6 on downstream shaping.

2.1.5.1.2 Downstream policing attributes

Each connection is policed to the product rate on ingress to the Cablelink port. The peak and prioritised rates along with their associated burst sizes are given in Table 2 below. The NGA network polices traffic at Layer 2 (i.e. Ethernet rate).

Product	Peak Rate (Mbps)	Peak Burst Size (B)	Prioritised Rate (Mbps)	Prioritised Burst Rate (B)
330/110M	330	204000	110	118000
160/110M	160	142000	110	118000

Table 2: Downstream policing parameters

2.1.5.2 Upstream

Figure 5 below outlines the upstream QoS for GEA-G.fast.

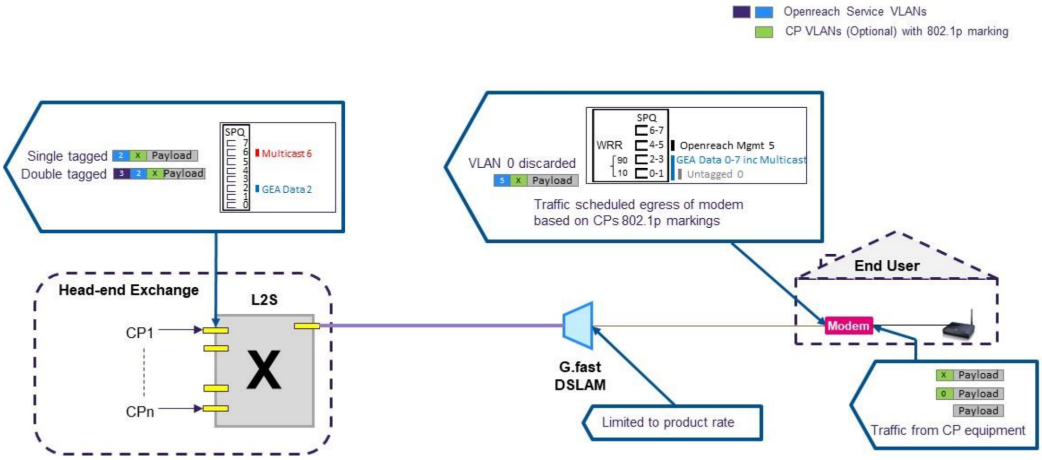

Openreach Service VLANs
CP VLANs (Optional) with 802.1p marking
Single tagged
2
X
Payload
Double tagged
3
2
X
Payload
SPQ
7
6
5
4
3
2
1
0
Multicast 6
GEA Data 2
VLAN 0 discarded
5
X
Payload
SPQ
6-7
WRR
4-5
90
2-3
10
0-1
Openreach Mgmt 5
GEA Data 0-7 inc Multicast
Untagged 0
Traffic scheduled egress of modem based on CPs 802.1p markings
End User
Head-end Exchange
L2S
CP1
CPn
X
G.fast DSLAM
Modem
Limited to product rate
X
Payload
0
Payload
Payload
Traffic from CP equipment

Figure 5 : Upstream QoS

CPs can (optionally) select the priority for each Ethernet frame via a VLAN PCP field sent into the Openreach modem from the CPE.

- Weighted 90:10 (High Priority: Low Priority)
  - 802.1p = 2 or 3 (4-7 will be treated as 3) → High priority
  - 802.1p = 0 or 1 or unmarked (no VLAN) → Low priority

High priority frames will be sent by the Openreach modem towards the DSLAM ahead of the low priority frames. As the prioritisation is weighted the low priority traffic will not be completely suppressed even if high priority traffic exceeds the line rate.

Handling of the VLAN tag by the Openreach modem varies:

- Tag = 0 → VLAN tag is stripped out by the Openreach NTE (802.1p field is still used for prioritisation)
- Tag ≠ 0 → VLAN tag will be forwarded to the CP (where this tag is forwarded, the CP must be able to handle this additional tag).

The above describes the behaviour of the Openreach G.fast modem. CPEs may employ alternative PCP based upstream marking schemes and number of priority levels. However, in both cases any PCP markings used to prioritise traffic upstream on to the G.fast line are overwritten by the DSLAM and therefore not preserved. All GEA Data traffic is presented at the Cablelink port with PCP = 2 in the C-VLAN for single tagged handover and in the outer S-VLAN and inner C-VLAN for double tagged handover.

Whether or not upstream QoS markings are used, the maximum upstream throughput may vary when compared with G.fast line rate. The actual variation in comparison with the G.fast line rate is up to 90% and 98% of line rate for 64 Byte and 1500 Byte packets respectively, and may be greater, depending on application.

Upstream traffic is not policed by the DSLAM or the Openreach G.fast modem. Instead upstream bandwidth is controlled by the upstream G.fast line rate.

2.1.6 Shaping

As SRA is active at the physical transmission layer for G.fast, any actual rate insertion cannot be relied upon by CP equipment as the active line rate will vary without any notification to CP equipment. The CP is therefore expected to shape, per end-user service, the downstream traffic to match the product rate or maximum attainable line rate (whichever is lower) and use prioritisation via 802.1p bits (per user) to ensure correct scheduling and prioritisation of traffic egress to the G.fast DSLAM interface.

The CP can use the performance metrics they receive from Openreach to update the traffic shaping.

See Section 2.1.7 for detailed rate insertion details.

Shaping equally applies upstream, see section 2.2.2 for details.

2.1.7 Intermediate Agent / DHCP Relay Agent / DHCP for IPv6

Where PPPoE is detected, additional tags will be inserted into the upstream flow (PADI) by the Intermediate Agent (IA) in the DSLAM. Any existing tags of the same type from the CPE will be overwritten. The IA tags will be removed by the DSLAM in the downstream direction (i.e. from the PADO, PADS messages).

Where DHCPv4 is detected, the DSLAM will insert Option 82 information field into the upstream flow (DHCP Discover). The Option 82 field will be removed by the DSLAM in the downstream response (DHCP Offer).

In addition where DHCPv6 (i.e. DHCP for IPv6) is detected, the DSLAM will insert and remove Options 18 (Circuit ID), 37 (Remote ID) and 17 (Vendor-specific Information; includes sub-options for reporting line characteristics such as line rate).

2.1.7.1 Supported Options

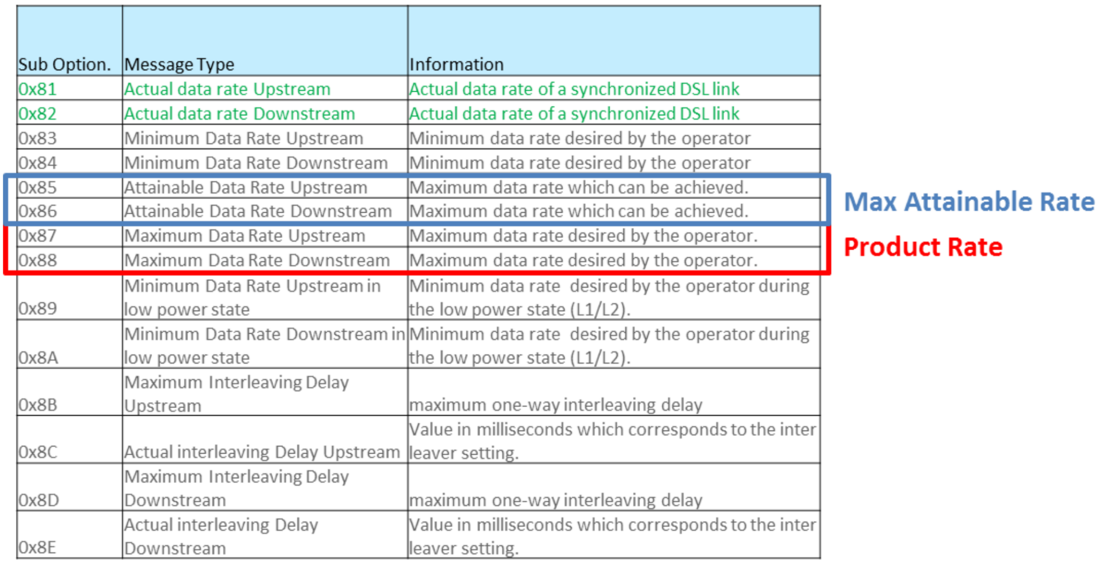
The following information will be supplied.

Note – any information in these fields from the end-user will be over-written.

- *Agent Remote ID* – 63 character field – value is either
    - Value supplied by CP during provide / modify order
        - From character set – a~z A~Z 0~9 @ . _ - ( ) / + : (Note space character is NOT supported)
        - Invalid characters in the order will cause order rejection

    or

    - DeviceName/S-VLAN ID/Frame No_Slot No_Port No/uservlan/C-VLAN ID if the CP does not set a value to be used
        - Changes if the port is changed for any reason – cannot be guaranteed to be constant
        - Any value supplied directly from any modem will be over-written
- *Agent Circuit ID*
    - Access-Node-Identifier eth frame/slot/port:c-vlan-id
        - The “frame/slot/port” value will change if the port used is changed after a port or card failure
- *Access Loop characteristics*
    - The entire access loop characteristics list is inserted for GEA-G.fast and the product and max attainable rates that the CP should shape to are highlighted below:



Sub Option.	Message Type	Information
0x81	Actual data rate Upstream	Actual data rate of a synchronized DSL link
0x82	Actual data rate Downstream	Actual data rate of a synchronized DSL link
0x83	Minimum Data Rate Upstream	Minimum data rate desired by the operator
0x84	Minimum Data Rate Downstream	Minimum data rate desired by the operator
0x85	Attainable Data Rate Upstream	Maximum data rate which can be achieved.
0x86	Attainable Data Rate Downstream	Maximum data rate which can be achieved.
0x87	Maximum Data Rate Upstream	Maximum data rate desired by the operator.
0x88	Maximum Data Rate Downstream	Maximum data rate desired by the operator.
0x89	Minimum Data Rate Upstream in low power state	Minimum data rate desired by the operator during the low power state (L1/L2).
0x8A	Minimum Data Rate Downstream in low power state	Minimum data rate desired by the operator during the low power state (L1/L2).
0x8B	Maximum Interleaving Delay Upstream	maximum one-way interleaving delay
0x8C	Actual interleaving Delay Upstream	Value in milliseconds which corresponds to the inter leaver setting.
0x8D	Maximum Interleaving Delay Downstream	maximum one-way interleaving delay
0x8E	Actual interleaving Delay Downstream	Value in milliseconds which corresponds to the inter leaver setting.

Table 3 : Access loop characteristics sub-options

- *Access Loop Encapsulation*
  - 0x90 – gives data link type, tagging, protocol info as per R-132 in TR-101 and is reported as "eth" for GEA-G.fast.

All of the above are formatted in accordance with Broadband Forum TR-101 0.

2.1.7.2 DHCPv4/v6 Port Numbers

The table below details the UDP port numbers that are expected in the DHCP messages as presented by the CPE to the DSLAM:

Scenario	**Expected Destination MAC address towards server**	**UDP Port numbers towards DSLAM**	**UDP Port numbers from DSLAM**
DHCPv4	Broadcast	Dst: 67, Src: 68	Dst: 68, Src: 67
DHCPv6	Multicast	Dst: 546, Src: 547	Dst: 547, Src: 546
DHCPv4 L2 Relay	Broadcast	Dst: 67, Src: 68	Dst: 68, Src: 67
DHCPv4 L3 Relay	Unicast	Dst: 67, Src: 67	Dst: 67, Src: 67
DHCPv6 L2 Relay	Multicast	Dst: 546, Src: 547	Dst: 547, Src: 546
DHCPv6 L3 Relay	Unicast	Dst:547, Src: 547	Dst:547, Src: 547

Table 4 : UDP port numbers for DHCP

The use of other UDP port numbers may result in the DHCP packets being silently discarded by the Openreach network.

The Openreach Lightweight DHCPv6 Relay Agent (LDRA) will present DHCPv6 messages at the Cablelink port as 'relay-forward' messages with both the destination and source UDP ports set to 547.

2.1.7.3 Inverted DHCP/PPPoE

The scenarios shown in the diagram below, where a DHCP Server or BRAS is located at an end-user's premises served by GEA-G.fast are not currently supported. This may result in dropped session initiation frames and will result in the scenarios below not being able to successfully operate.

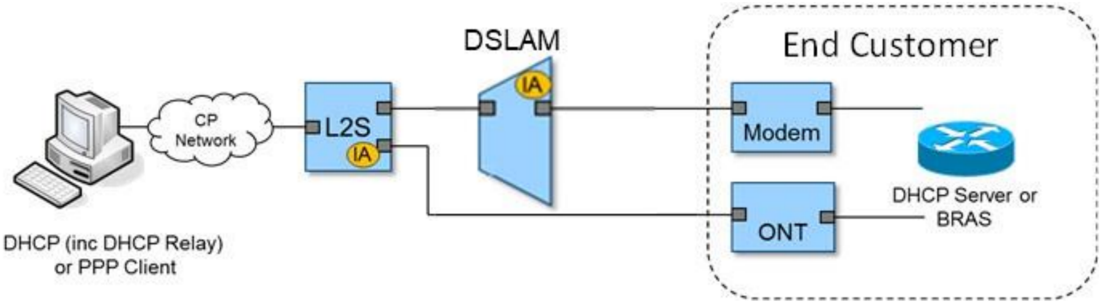

DSLAM
End Customer
CP
Network
L2S
IA
IA
Modem
ONT
DHCP Server or
BRAS
DHCP (inc DHCP Relay)
or PPP Client

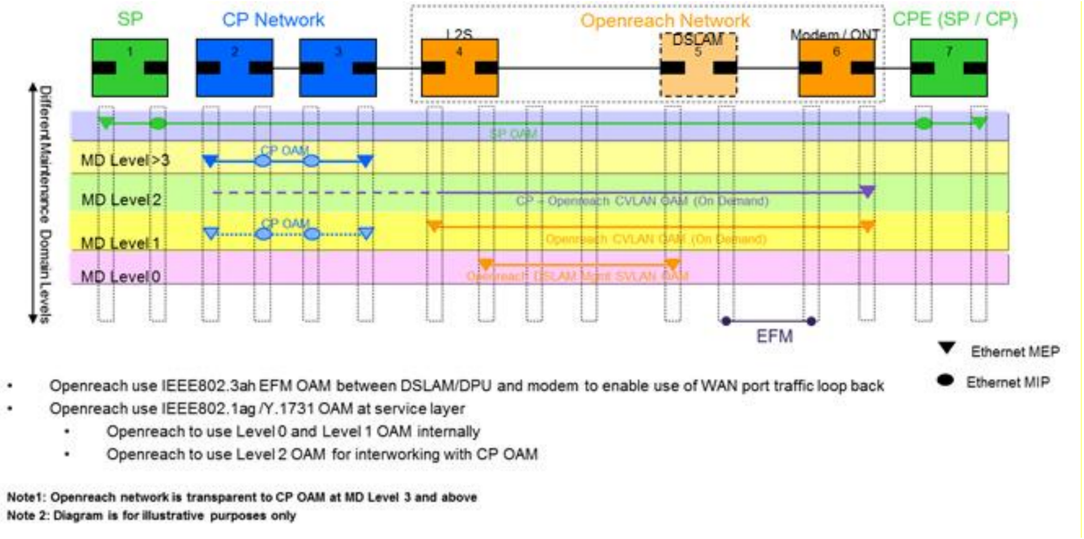
Figure 6 : Inverted DHCP/PPPoE

2.1.8 Ethernet OAM

Openreach provides CPs with the ability to test their GEA-G.fast circuits end-to-end between the CP's equipment and the Openreach provided NTE. To do this CPs need to use Multicast Loopback Messages (MC LBMs) as described in Y.1731 [11] at Maintenance Domain (MD) Level 2 with a destination MAC address of 01-80-C2-00-00-32.

In addition, CPs can send Ethernet OAM information end-to-end across their GEA-FTTC connection at MD Levels 3 and above.

An interworking overview of OAM is shown in Figure 7 and Figure 8 below.


SP
CP Network
Openreach Network
CPE (SP / CP)
L2S
DSLAM
Modem / ONT
1
2
3
4
5
6
7
Different Maintenance Domain Levels
SP OAM
MD Level>3
CP OAM
MD Level 2
CP - Openreach CVLAN OAM (On Demand)
MD Level 1
CP OAM
Openreach CVLAN OAM (On Demand)
MD Level 0
Openreach DSLAM Mgmt SVLAN OAM
EFM
Ethernet MEP
Ethernet MIP

- Openreach use IEEE802.3ah EFM OAM between DSLAM/DPU and modem to enable use of WAN port traffic loop back
- Openreach use IEEE802.1ag /Y.1731 OAM at service layer
  - Openreach to use Level 0 and Level 1 OAM internally
  - Openreach to use Level 2 OAM for interworking with CP OAM

Note1: Openreach network is transparent to CP OAM at MD Level 3 and above
Note 2: Diagram is for illustrative purposes only

Figure 7 : OAM Interworking – Maintenance Domain Levels

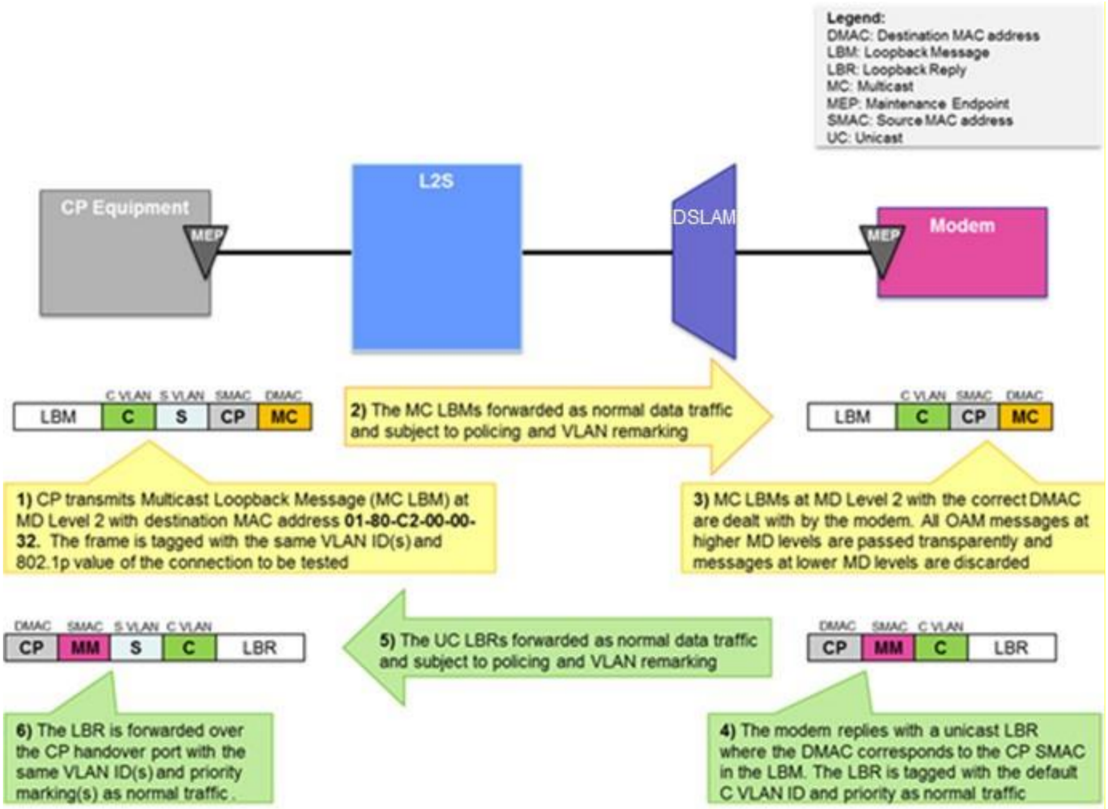

Legend:
DMAC: Destination MAC address
LBM: Loopback Message
LBR: Loopback Reply
MC: Multicast
MEP: Maintenance Endpoint
SMAC: Source MAC address
UC: Unicast
CP Equipment
MEP
L2S
DSLAM
MEP
Modem
C VLAN
S VLAN
SMAC
DMAC
LBM
C
S
CP
MC
2) The MC LBMs forwarded as normal data traffic and subject to policing and VLAN remarking
C VLAN
SMAC
DMAC
LBM
C
CP
MC
1) CP transmits Multicast Loopback Message (MC LBM) at MD Level 2 with destination MAC address 01-80-C2-00-00-32. The frame is tagged with the same VLAN ID(s) and 802.1p value of the connection to be tested
3) MC LBMs at MD Level 2 with the correct DMAC are dealt with by the modem. All OAM messages at higher MD levels are passed transparently and messages at lower MD levels are discarded
DMAC
SMAC
S VLAN
C VLAN
CP
MM
S
C
LBR
5) The UC LBRs forwarded as normal data traffic and subject to policing and VLAN remarking
DMAC
SMAC
C VLAN
CP
MM
C
LBR
6) The LBR is forwarded over the CP handover port with the same VLAN ID(s) and priority marking(s) as normal traffic.
4) The modem replies with a unicast LBR where the DMAC corresponds to the CP SMAC in the LBM. The LBR is tagged with the default C VLAN ID and priority as normal traffic

Figure 8 : OAM Interworking – Operation

2.1.9 Transparency

GEA-G.fast will not be transparent to:

- 802.3x PAUSE – Local link flow control protocol
- Slow Protocols – Set of protocols that includes LACP and 802.3ah OAM
- 802.1X Authentication – Authentication protocol
- Physical layer signalling such as auto-negotiation

2.1.10 Frame Duplication

CP equipment must observe Ethernet bridging rules. In particular frames sent from Openreach to the CP must not be reflected back to the Openreach network with source MAC unaltered. This applies both downstream at the Cablelink port and upstream at the modem or DSL port.

2.1.11 Multicast

The IP source address of IGMP queries sent downstream towards the end-user equipment will be 0.0.0.0. Otherwise the multicast service will support the same features as detailed in SIN 498 and SIN 503.

Since the multicast MAC address is derived from the IP group address, CPs shall ensure that IP group addresses are unique in the lower 23 bits.

2.1.12 Network Timing Reference (NTR)

Openreach is currently investigating the support of synchronisation on G.fast. This will require, at high level the CP G.fast modem to support:

- G.fast NTR on the network side
- Sync support on the Ethernet side (SyncE + 1588v2)
- Any environmental outdoor usage specification depending on what synchronisation is used for.

A complete description of these requirements will be included in a future revision of this document if synchronisation is required.

2.2 User Network Interface – General

2.2.1 Dynamic Line Management

Dynamic Line Management (DLM) will be used on G.fast lines. DLM monitors and manages lines to maintain a target link quality (speed and stability). DLM runs once a day based on line performance data collected during the previous day and makes changes in the G.fast line configuration if needed. Two parameters can be varied by DLM within the line configuration; the level of retransmission or the target noise margin. DLM operates independently on the downstream and upstream channels, although the same process is applied in each direction.

For poor lines (i.e. those not meeting the target link quality) increasing the level of retransmission is chosen in preference to increasing the target margin by DLM. Once the highest level of retransmission is reached then target margin is increased until the target link quality is achieved. For good lines (i.e. lines running in excess of the target link quality) a reduction in the target margin is chosen in preference to reducing the level of retransmission. If a line meets the target link quality, then DLM will take no action.

Retransmission is applied by default in both the downstream and upstream channels at a low level to all new lines and is then increased by DLM if needed. In addition, maximum line rate caps are applied by default and within the DLM process which align to the selected product (i.e. the 330 Mbit/s product will be capped at a maximum Ethernet throughput rate of 330 Mbit/s).

Note: It is the DLM system that sets the line profile, and this should not be interfered with by CPs/users setting rates, SNR margins etc. at the modem.

2.2.2 Upstream shaping

To avoid excessive traffic loss the CP is expected to shape the upstream traffic to match at least the lower of:

- Actual maximum attainable G.fast line rate (see section 2.1.7 Intermediate Agent/DHCP Relay Agent); or
- The upstream rate that has been purchased.

In addition, CPs should consider the impact of upstream capacity on their GEA Cablelink.

- Openreach will shape traffic into the GEA Cablelink. This shaping will treat all GEA-FTTC Data traffic equally. Specifically, it will not make use of any markings applied by the CPE.
- Openreach will explicitly not manage traffic at an individual inner tag or outer tag level.

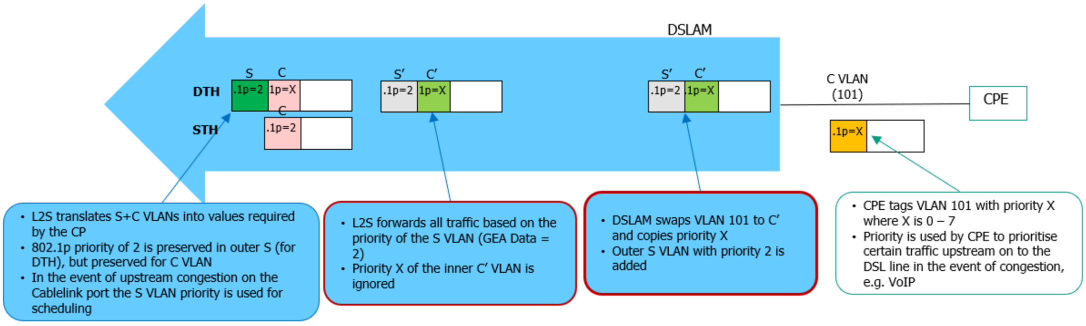
2.2.3 Upstream priority marking

CPs can (optionally) select the priority for each Ethernet frame via a VLAN PCP field sent into the Openreach modem from CPE.

- PCP = 2 or 3 (4-7 will be treated as 3) → High priority
- PCP = 0 or 1 or unmarked (no VLAN) → Low priority

High priority frames will be sent by the Openreach modem toward the DSLAM ahead of the low priority frames. This prioritisation will be weighted i.e. the low priority traffic will not be completely suppressed even if high priority traffic exceeds the line rate.

Any priority that is set on the X-VLAN will be preserved in the C-VLAN for DTH. This is shown in Figure 9 - X-VLAN tagging


DSLAM
DTH
STH
S
C
.1p=2
1p=X
C
.1p=2
S′
C′
.1p=2
1p=X
S′
C′
.1p=2
.1p=X
C VLAN
(101)
CPE
.1p=X

- L2S translates S+C VLANs into values required by the CP
- 802.1p priority of 2 is preserved in outer S (for DTH), but preserved for C VLAN
- In the event of upstream congestion on the Cablelink port the S VLAN priority is used for scheduling

- L2S forwards all traffic based on the priority of the S VLAN (GEA Data = 2)
- Priority X of the inner C′ VLAN is ignored

- DSLAM swaps VLAN 101 to C′ and copies priority X
- Outer S VLAN with priority 2 is added

- CPE tags VLAN 101 with priority X where X is 0 – 7
- Priority is used by CPE to prioritise certain traffic upstream on to the DSL line in the event of congestion, e.g. VoIP

Figure 9 - X-VLAN tagging

Handling of the VLAN tag by the Openreach modem varies:

- Tag = 0 → VLAN tag is stripped out by the Openreach modem (PCP field is still used for prioritisation). VLAN 0 is not reinstated by the modem in the downstream direction
- Tag ≠ 0 → VLAN tag will be forwarded to the CP
(where this tag is forwarded, the CP must be able to handle this additional tag)

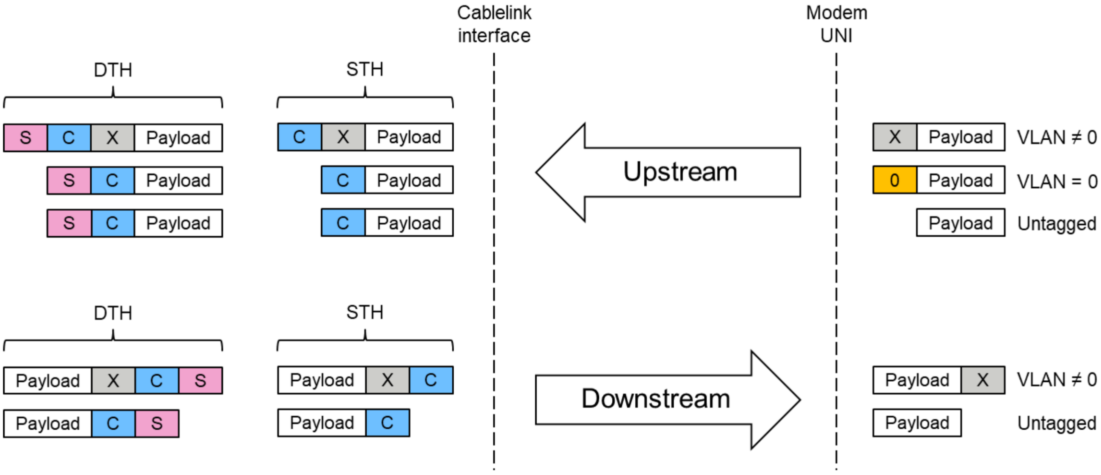

Cablelink
interface
Modem
UNI
DTH
STH
S
C
X
Payload
S
C
Payload
S
C
Payload
C
X
Payload
C
Payload
C
Payload
Upstream
X
Payload
VLAN ≠ 0
0
Payload
VLAN = 0
Payload
Untagged
DTH
STH
Payload
X
C
S
Payload
C
S
Payload
X
C
Payload
C
Downstream
Payload
X
VLAN ≠ 0
Payload
Untagged

Figure 10: Upstream and downstream VLAN forwarding and manipulation

The above describes the behaviour of the Openreach G.fast modem. CPEs may employ alternative PCP based upstream marking schemes and number of priority levels. However, in both cases any PCP markings used to prioritise traffic upstream on to the G.fast line are overwritten by the DSLAM and therefore not preserved. All GEA-G.fast traffic is presented at the Cablelink port with PCP = 2 in the C-VLAN for single tagged handover, and in the outer S-VLAN and inner C-VLAN for double tagged handover

Whether or not upstream QoS markings are used, the maximum upstream throughput may vary when compared with G.fast line rate. The actual variation in comparison with the G.fast line rate is up to 90% and 98% of line rate for 64 byte and 1500 byte packets respectively, and may be greater, depending on application.

2.2.4 UNI Port Loopback Testing

Test and diagnostic action will require an Ethernet port loopback to be applied to the modem port in order to loop downstream traffic back upstream to the Openreach test head or CP test head. These tests will interrupt upstream traffic from the end-user and should therefore only be enabled with the end-user's consent. The end-user must also agree to stop any downstream Multicast Service traffic and power off their Set Top Box if they have one, as any GEA-G.fast Multicast VLAN traffic may interfere with testing on the GEA-G.fast Data VLAN.

In addition, once the port loopback has been enabled, unicast test traffic initiated by the user can be used to test connectivity and maximum upstream throughput.

2.3 Openreach Provided and installed Modem Product Variant

2.3.1 Use of NTEs

Openreach engineers will install a "Service Specific Face Plate (SSFP)" to the Openreach line box (i.e. NTE5) and Openreach G.fast modem in the premises as shown in Figure 11.

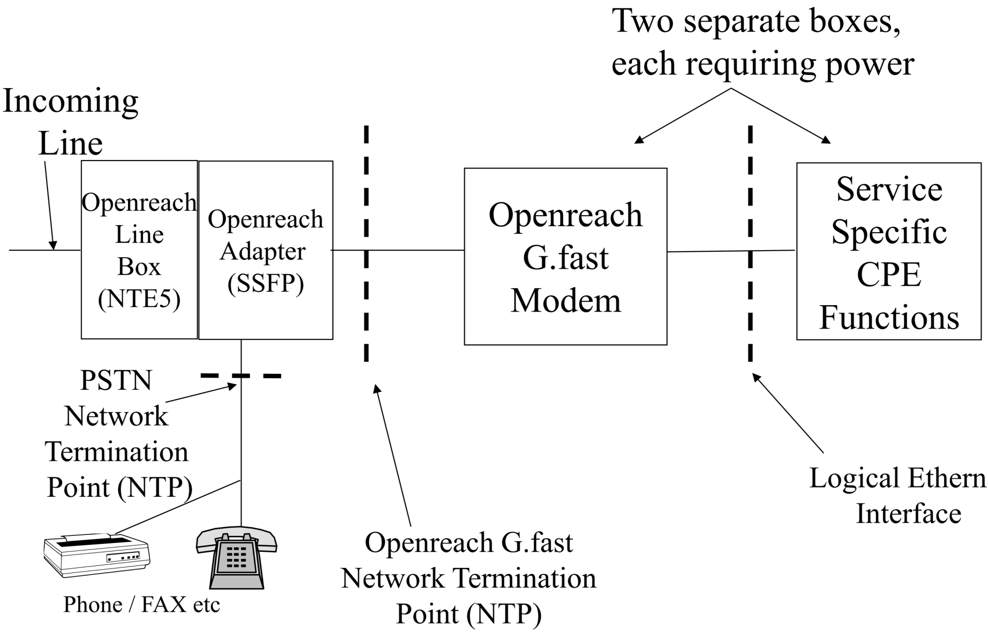

Two separate boxes, each requiring power
Incoming Line
Openreach Line Box (NTE5)
Openreach Adapter (SSFP)
Openreach G.fast Modem
Service Specific CPE Functions
PSTN Network Termination Point (NTP)
Phone / FAX etc
Openreach G.fast Network Termination Point (NTP)
Logical Ethernet Interface

Figure 11 : Openreach Installed Centralised Filter Topology

The purpose of the SSFP is to isolate the high frequency G.fast signals from existing legacy products/wiring within the end-user premises to prevent service degradation on those products.

The SSFP will fit to an NTE5C only. If any other type of NTE is present at the end-user premises, the Openreach engineer will change this as part of the service provision visit.

If a CP chooses to offer a self-install solution for the Openreach provided modem, then they must in addition adhere to sections 2.4.1 and 2.4.2 for filters and Physical Network Termination specifications

The requirements for this SSFP are defined in Section 3.2.6.

Please refer to STIN517 for SOGFAST.

2.3.2 Openreach NTE

For G.fast the Openreach NTE will be a modem. The active Ethernet end-user port (i.e. Port LAN1) on the G.fast modem will be set to:

- 10/100/1000 Base-Tx Auto-negotiation (with RJ-45 connectivity) NOTE: this necessitates that the CPs Hub or router device shall support 10/100/1000BaseT interface to ensure the interfaces negotiate to 1000BaseT, otherwise the product speeds cannot be supported,
- Auto-negotiation and MDI/MDIX auto-sensing.

Data transfer supported at the G.fast line rate for all frame sizes. The Openreach G.fast NTE shall have a Gigabit Ethernet interface.

The technical specification of the interface connections provided by the NTE device is described in SIN 3600.

2.3.2.1 Electrical Safety

The Openreach G.fast NTE is compliant with BS EN 60950-1.

2.3.2.2 Location of NTE

The Openreach NTE will normally be wall mounted within the end-user's premises, although it is safe to operate freestanding in either the horizontal or vertical plane. The NTE should not be stacked under/over other items that would impede air flow or prevent the unit dissipating heat.

2.4 CP provided G.fast Modem product variant

Openreach support a GEA-G.fast product variant that allows the CP to provide and be responsible for the user's G.fast modem. Typically, this modem will be integrated with IP gateway functionality within a single device and connected to a single mains power source. CPs will be responsible for maintaining the firmware of their modems and monitoring their connectivity and performance typically via a TR-069 0 interface using CPE WAN management protocol (CWMP).

The CP provided modem and filtering device(s) must meet the requirements of this specification in order to provide reliable operation and to avoid harm to other VDSL2 and/or G.fast lines sharing the same cable binder. Openreach reserves the right to withhold or limit service where potential violation of the Access Network Frequency Plan (ANFP 0) or impact to another customer's service is detected.

The detailed technical requirements for CP provided G.fast modems are defined in Section 3 of this document and the related test descriptions required to demonstrate compliance to these requirements are currently being developed.

CPE connected to Openreach's network will be expected to be upgraded to remain compliant with the evolving Openreach network, as reflected in changes in this SIN.

2.4.1 Physical Network Termination

Openreach provide a metallic line with a line box, also known as a Network Terminating Equipment (NTE). The physical interface is the standard telephone socket on the line box as described in SIN 3510.

The CP must supply a suitable filter that plugs into the NTE and a modem device which plugs into the filter. This filter is required to separate PSTN and G.fast signals carried on the same line. Two possible connection topologies exist for these filters:

Using a CP supplied, single, self-installed CPE G.fast centralised filter deployed between the line box and all PSTN CPE (centralised filter topology – see Figure 13). The requirements for this centralised filter are defined in Section 3.2.6.1.

Using multiple CP supplied self-installed CPE G.fast in-line micro filters, one for each device plugged into the wired extensions off the line box (distributed filter topology – see Figure 12). The requirements for this distributed filter are defined in Section 3.2.6.2.

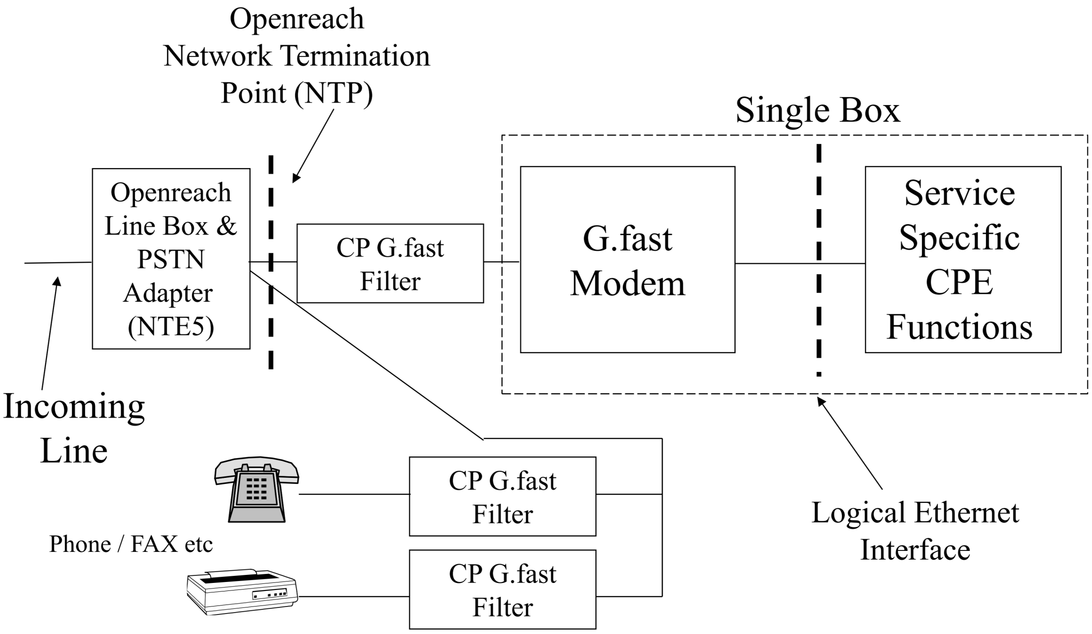

Openreach
Network Termination
Point (NTP)
Single Box
Openreach
Line Box &
PSTN
Adapter
(NTE5)
CP G.fast
Filter
G.fast
Modem
Service
Specific
CPE
Functions
Incoming
Line
CP G.fast
Filter
Phone / FAX etc
CP G.fast
Filter
Logical Ethernet
Interface

Figure 12 : Distributed Filter Topology

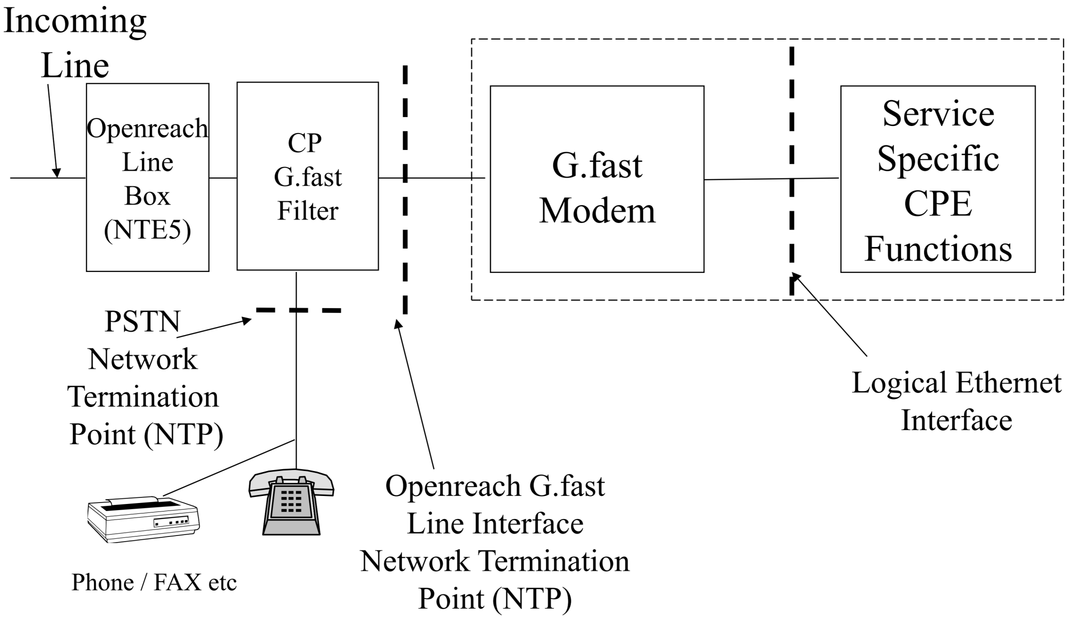

Incoming Line
Openreach Line Box (NTE5)
CP G.fast Filter
G.fast Modem
Service Specific CPE Functions
PSTN Network Termination Point (NTP)
Phone / FAX etc
Openreach G.fast Line Interface Network Termination Point (NTP)
Logical Ethernet Interface

Figure 13 : Centralised Filter Topology

2.4.2 Filter Installation Topology

In the cases outlined in Figure 12 and Figure 13, the filters are classed as Customer Premises Equipment (CPE) and could be deployed in two distinct topologies. Either multiple distributed CP filters can be used as in the arrangement shown in Figure 12, or a single centralised in-line filter can be provided as in the arrangement shown in Figure 13. In all cases, there must be a filter function between the line-box and any item of PSTN CPE, including extension telephones, modems, fax machines, set-top boxes etc.

When CP G.fast filters are used, the network termination point (NTP) for G.fast services to which this SIN relates, is located at the Line-box. However the physical G.fast modem may be connected into one of the G.fast CP filters as shown in Figure 12, or into a centralised filter as shown in Figure 13.

Note that when a centralised CPE G.fast filter is in use as shown in Figure 13, the G.fast modem can ONLY be connected at the line-box, as the filter prevents the G.fast signal reaching the extension sockets.

For either of the above filter deployment scenarios, the CP shall ensure that the lead which is provided to connect the modem to the filter is of a suitable quality to optimise G.fast performance (e.g. a minimum of UTP Category 5 cable).

3. CPE Requirements For GEA-G.fast

This section defines the requirements of CP provided modems that must be met for connection to Openreach User Network Interface (UNI). These requirements include logical functions within the CPE necessary to support and maintain Openreach services delivered over GEA-G.fast.

The nomenclature used for each requirement is R.X.Y where:

R stands for requirement

X is the category (PHY, FAST, ETH, WAN, OAM, Filter)

Y is the requirement number

In this section the term “modem” refers to the CP provided modem and “WAN Interface” refers to the interface on the modem connecting to the Openreach NGA network.

3.1 Scope

The protocol layers within this scope are depicted in Figure 14.

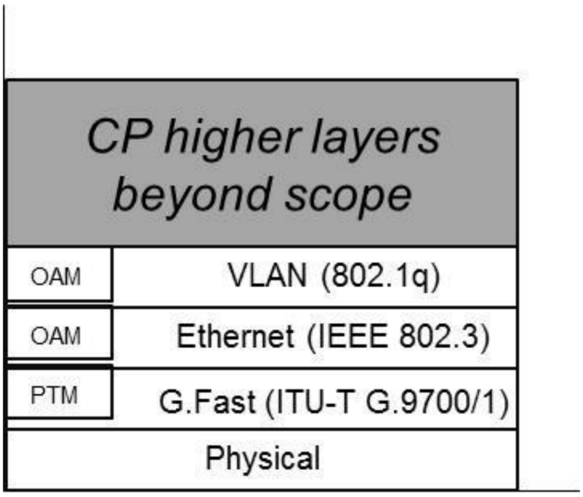


Figure 14 : Protocol Layers in Scope for GEA

3.2 Requirements

The CP provided modem shall support all the requirements as described in the following subsections. Additional guidance is also provided as a “Note” where appropriate.

A full description of the tests required to demonstrate compliance with these requirements is detailed in Annex B of this document.

3.2.1 Physical Connection

R.PHY.1 The socket on the modem connecting to the Openreach UNI (i.e. WAN port) shall be either a RJ11 or RJ45 type to enable it to be connected to the G.fast filter using standard leads. The

G.fast connection is presented on the middle two pins (i.e. pins 3&4 (RJ11) or pins 4&5 (RJ45)). The other pins are not connected. Pin numbering is from the left, looking into the socket with the contacts uppermost. Polarity is unimportant.

Note: Openreach do not currently offer a bonded G.fast product (where two or more G.fast lines are connected to one modem device to increase bandwidth). This SIN will be updated if and when Openreach offer this feature.

3.2.2 G.fast Requirements

R.FAST.1 The CP or their equipment supplier shall demonstrate that their G.fast WAN modem chip-set or CPE device has successfully passed BBF G.fast Certification (based around BBF IR-337).

R.FAST.2 CP modems shall support the mandatory requirements of ITU-T Recommendations G.9700 and G.9701 including subsequent Corrigenda and Amendments as consented / approved.

R.FAST.3 CP modems shall support ITU-T Recommendations G.9700 and G.9701 profile 106a and profile 106b. If 106b is not supported, performance may be materially impacted.

R.FAST.4 CP modems shall meet the requirements of the UK Access network Frequency Plan (ANFP) 0 and the specification in Part F.

R.FAST.5 CP modems shall use handshake tone-set AA43C as defined in ITU-T Recommendation G.994.1 0. In addition, these tones shall be shaped to comply with the requirements of Sections 4.1 or 4.4 of the UK ANFP. The use of additional tone-sets (B43, B43c, V43 etc.) is not permitted as these may cause adverse interference to other DSL systems operating in the same cable binder.

R.FAST.6 CP modems shall be spectrally compatible with other 17.664 MHz VDSL2 services when operating in G.fast mode.

R.FAST.7 CP modems shall be capable of supporting an aggregate (i.e. upstream plus downstream) bandwidth of 1Gbit/s for 2 to 106 MHz operation.

R.FAST.8 CP modems shall support downstream and upstream retransmission as defined in G.9701, clauses 9.8.3.3, 11.4.2.6 and 11.4.2.7

R.FAST.9 CP modems shall support vectoring in both upstream and downstream directions as defined in G.9701, clauses 10.3, 10.8 and 11.4.3.

R.FAST.10 CP modems shall support Seamless Rate Adaptation (SRA) as defined in G.9701, clause 13.2.1.1

R.FAST.11 CP modems shall support Fast Rate Adaption (FRA) as defined in G.9701, clause 13.3.1.1.

R.FAST.12 CP modems should have a receiver noise floor of less than -150 dBm/Hz.

R.FAST.13 CP modems should support a maximum Aggregate Transmit Power (ATP) of 8 dBm in the upstream direction.

R.FAST.14 CP modems shall support a maximum Aggregate Transmit Power (ATP) of 8 dBm in the downstream direction.

R.FAST.15 CP modems should be capable of transmitting at PSDs of up to -65 dBm/Hz at frequencies up to 30 MHz.

R.FAST.16 CP modems shall be capable of supporting TDD frame lengths of 36 symbol periods as defined in G.9701 clause 10.5. For a 36 symbol frame, the current default downstream to upstream ratio used by Openreach is 83:17 (i.e. 29 downstream symbols to 6 upstream symbols).

NOTE – The ITU-T G.9701 Recommendation also specifies the support of 23 symbol TDD frames. Currently this option is not supported by Openreach. This SIN will be updated if this changes.

R.FAST.17 CP modems shall correctly report DFT output samples (as defined in G.9701 clause 10.3.2.2) and MREFPSDus (as defined in G.9701 clause 7.3.2) to support the correct computation of downstream and upstream Hlog as defined in G.9701 clause 11.4.1.2.1.

R.FAST.18 CP modems shall correctly report DFT output samples (as defined in G.9701 clause 10.3.2.2) to support the correct computation of upstream Quite Line Noise (QLN) as defined in G.9701 Clause 11.4.1.2.3.

R.FAST.19 CP modems shall correctly report Active Line Noise (ALN) as defined in G.9701 Clause 11.4.1.2.4.

R.FAST.20 CP modems shall support low power modes as defined in G.9701 clause 11.2.2.16. In addition, the G.fast modem shall use a traffic driven control method for low power modes as defined in G.9701 clause 11.2.2.16.

R.FAST.21 CP modems shall correctly report inventory information as defined in G.994.1, clause 9.3.3.1 and G.9701, clause 11.2.2.10. Specifically, this shall include vendor ID, version number and serial number. Coding for the vendor ID information block is shown in Table 5. Non-printable ASCII characters (e.g. CR, LF, FF), delete (DEL) and comma (,) shall not be used.

NOTE – This field should typically identify the vendor of the ITU-T G.994.1 functionality, whether implemented in hardware or software. It is not intended to indicate the system integrator.

T.35 country code (2 octets – Note 1)
Provider code (vendor identification) (4 octets – Note 2)
Vendor-specific information (2 octets)
NOTE 1 – If the bits in the first octet are not all set to binary ONE, the bits in the second octet shall be set to binary ZERO by the transmitter and ignored by the receiver. The only purpose of the country code is to identify the country of registry of the provider code. NOTE 2 – Specification of the coding and order of transmission of this field is the responsibility of the regional standards body allocating the provider code. See Appendix II of G.994.1 for provider code contact information.

Table 5 : Vendor ID information block

R.FAST.22 CP modems shall support a bit loading of at least 14 bits/tone in both upstream and downstream directions.

R.FAST.23 CP modems shall correctly report performance data as defined in Section 7 of G.997.2.

R.FAST.24 CP Modems shall support RFI and IAR (International Amateur Radio) notching as defined in G.9700, clauses 6.5 and 7.2.1 and G.9701, clause 7.3.1.2.

R.FAST.25 CP modems shall support upstream power back-off (UPBO) as defined in G.9701, clauses 7.3.1 and 7.3.1.4.

R.FAST.26 CPE vendor information shall be reported as shown in Table 6. Non-printable ASCII characters (e.g. CR, LF, FF), delete (DEL) and comma (,) shall not be used.

Attribute (G.997.2 Clause)	**Description (Format)**	**Examples**
FTUR_GHS_VENDOR (7.13.1.2)	FTU-R ITU-T G.994.1 Vendor ID (8 binary octets)	xx:00:11:22:33:44:55:66 (where xx is the ITU-T T.35 country code) and 11:22:33:44 is the Provider code)
FTUR_VERSION (7.13.1.4)	FTU-R Version Number (Up to 16 ASCII characters as: <FTU-R firmware version><space><FTU-R model>). In this context FTU-R refers to the G.9701 chipset	
NT_SYSTEM_VENDOR (7.13.2.2)	NT system G.9701 vendor ID (8 binary octets). Refers to system integrator of smallest field replaceable unit, in this case the CPE.	xx:00:11:22:33:44:55:66 (where xx is the ITU-T T.35 country code)
NT_SYSTEM_SERIALNR (7.13.2.4	NT system G.9701 serial number (Up to 32 ASCII characters as: <NT serial number><space><NT model><space><NT firmware version>). Refers to system integrator of smallest field replaceable unit, in this case the CPE.	

Table 6 : CPE Vendor Information block

NOTE: Once the Broadband Forum has published TR-380 (G.fast performance test suite), Openreach will expect CP modems to deliver or exceed the specified performance targets.

NOTE: Openreach does not currently offer a timing reference source solution over G.fast. CP's seeking to implement a timing reference source for future functionality should consider NTR as per G.9701.

NOTE: CP's shall undertake to remotely manage the upgrade and roll-back of their modem firmware to enable mitigation of future network changes on their live modem population.

R.FAST.27 CP modems shall support bit swap in both directions.

R.FAST.28 CP modems shall support sub-carrier masking (aka tone blackout) in both directions.

R.FAST.29 CP modems shall support Minimum ANDEFTR per time interval (Minimum of the 1 second averages of rate (kbit/s)) as defined in G.997.2 clause 7.8.9

R.FAST.30 CP modems shall support Maximum ANDEFTR per time interval (Maximum of the 1 second averages of rate (kbit/s)) as defined in G.997.2 clause 7.8.10

R.FAST.31 CP modems shall support Sum ANDEFTR per time interval (Sum of ANDEFTR of the period in (units 65536 bits)) as defined in G.997.2 clause 7.8.11

R.FAST.32 CP modems shall support ANDEFTRDS counter (Sum of ANDEFTR of the period in (units 65536 bits)) as defined in G.997.2 clause 7.8.8

R.FAST.33 CP modems shall support LANDEFTRS counter (Count of seconds during which ANDEFTR was below threshold) as defined in G.997.2 clause 7.8.7

Note: Should also consider collecting SRA/FRA and retransmission related parameters to aid interpretation of ANDEFTR parameters.

R.FAST.34 CP modems shall support "landeftr" defect threshold (Used to trigger the LANDFTER counter, given focus on the 100 Mb/s point. Suggest DS set to 100 Mb/s and US set to 20 Mb/s)) as defined in G.997.2 clause 7.2.4.1

3.2.3 Ethernet Layer

R.ETH.1 The modem shall support an Ethernet frame size of between 68 and 1522 bytes at the WAN interface. Support of frame sizes between 1522 - 1534 bytes is optional. For clarity this figure includes 4 bytes for the C VLAN and excludes bits allocated to pre-amble, Inter-frame Gap and Frame Check Sequence at the User Network Interface (UNI).

NOTE: The GEA Data service supports a maximum frame size of 1534 bytes at the G.fast interface (including C VLAN). Frame sizes above 1534 bytes (including C VLAN) is not guaranteed.

NOTE: The CPs G.fast modem shall support a 10/100/1000BaseT interface to ensure any interfaces negotiate to 1000BaseT as otherwise the product speeds cannot be supported

3.2.4 WAN VLAN Layer

R.WAN.1 Withdrawn

R.WAN.2 All ingress frames to the Openreach UNI shall be encapsulated within an IEEE 802.1q VLAN (C-VLAN) with a value of 101 which will be used for switching within the Openreach network.

R.WAN.3 Where the CP intends to use Multicast for GEA, the modem shall be capable of simultaneously supporting Multicast and Unicast over the same single-tagged VLAN.

R.WAN.4 The Ethertype (Tag Protocol Identifier) field of the Ethernet frame shall be set to 0x8100 on ingress to Openreach UNI. On egress, Openreach will also set this field to 0x8100.

R.WAN.5 The C VLAN Canonical Format Indicator shall be zero on ingress to the Openreach UNI. Openreach will set this to zero towards the modem.

R.WAN.6 Where the CP intends to use GEA data and Multicast for GEA services the VLAN ID shall be set to 101 (ingress and egress). Traffic without a correct VLAN ID will be dropped.

R.WAN.7 Where the CP intends to use Multicast, IGMP reports destined for Openreach Multicast for GEA shall be encoded as IGMPv3 or IGMPv2 over C VLAN ID 101. Source Specific Multicast option within IGMPv3 must not be used.

R.WAN.8 Where the CP is using PPP and intends to use Multicast for GEA, the modem shall be able to detect and process multicast frames differently to unicast. Multicast for GEA frames sent into Openreach (IGMP reports) shall not be encapsulated with PPP otherwise they will be passed transparently as normal GEA traffic.

NOTE: In addition to the Openreach requirements set herein, the modem should also support NICC Ethernet ALA Service Definition 0.

NOTE: Scheduling priority to the upstream G.fast line speed is a function within the modem. If different traffic QoS levels are to be supported, careful consideration should be given to the potential for starvation of low priority queues within the modem and the impact this might have on the user experience and fault rates.

NOTE: It is recommended that IGMP membership reports are given a high queue scheduling priority.

NOTE: Where the modem is configured with an IGMP proxy function, it may be useful to know that the Openreach Multicast for GEA will accept IGMP packets with any unicast source address, including 0.0.0.0.

NOTE: Modem providers are urged to pay close attention to the challenges of IPv6 support. Openreach currently provide DHCP Option 82 insertion support for IPv4. To ensure the equivalent is supported in future IPv6 networks, namely Lightweight DHCPv6 Relay Agent, modem vendors should implement DHCPv6 in accordance to BBF TR-177 0[and referenced IETF standards within that document. Close attention to on-going developments of these documents is also recommended.

NOTE: Openreach expect CPs to only configure their devices for and send traffic for GEA Data on VLAN101. No other VLANs should be used and if they are then this may impact service. In addition, Openreach may use other VLAN tags on the DSLAM access port for internal use, traffic from any other VLANs apart from VLAN 101 should be ignored/dropped.

3.2.5 Ethernet OAM

R.OAM.1 CP modems shall support “Dying Gasp” as defined in G.9701, clause 11.3.3.2.

R.OAM.2 The CPE G.fast port shall have EFM OAM permanently enabled and configured in Passive mode in order to maintain a permanent OAM session with the Active DSLAM. It shall never be possible to set the modem EFM OAM mode to Active.

R.OAM.3 The CP modem shall support the EFM OAM loopback capability as per IEEE 802.3 Clause 57.2.11.

R.OAM.4 The EFM OAM loopback capability shall return downstream Ethernet test traffic back upstream towards the DSLAM on C VLAN 101. The loopback shall be initiated and terminated by the DSLAM via the appropriate EFM OAMPDU messaging.

R.OAM.5 Openreach require to collect the statistics defined in IEEE 802.3.1-2013 Annex B before and after a speed test (initiated from Central Test Head) to calculate throughput and loss based on the counter increments. Details of the statistics are provided in Table 7.

R.OAM.6 The receive and transmit statistics detailed in Table 7 must be collected on the WAN side of the EFM OAM loopback capability in the CPE in order for the statistics counters to increment whilst the loopback is in place.

IEEE Std 802.3 Clause 30 object name	BRANCH	LEAF
aFramesTransmittedOK	7	2
aFramesReceivedOK	7	5
aOctetsTransmittedOK	7	8
aOctetsReceivedOK	7	14
aMulticastFramesXmittedOK	7	18
aMulticastFramesReceivedOK	7	21
aBroadcastFramesXmittedOK	7	19
aBroadcastFramesReceivedOK	7	22
aFrameCheckSequenceErrors	7	6
aFramesTooLong	7	56
aRunts	7	58

Table 7 : OAM Statistics

NOTE: Retrieval of statistics from a CPE will be initiated by Openreach.

NOTE: The DSLAM will transmit a Variable Request OAMPDU to the CPE as defined in IEEE 802.3-2012 Section 5 Clause 57.4.3.3 containing a list of predetermined set of statistics that are to be retrieved from the CPE.

R.OAM.7 The CPE shall respond with the values for each statistic by transmitting a Variable Response OAMPDU as defined in IEEE 802.3-2012 Section 5 Clause 57.4.3.4 back to the DSLAM.

NOTE: The statistics are then displayed on the EMS GUI and forwarded to Openreach test systems.

R.OAM.8 (a) The modem WAN interface shall support Loopback Messages (LBM) as described in ITU-T Y.1731 0.
(b) The modem shall respond to LBM over VLAN ID 101 with a Loopback Reply Message (LBR), at MD Level 1. The LBM destination MAC address could be either multicast or unicast, both shall be supported. The multicast destination address for the LBMs at MD level 1 is 01-80-C2-00-00-31.

MD Level 1 is reserved exclusively for Openreach and shall not be used by CPs. MD Level 2 and above are allocated for CP use, e.g. loopback. The Openreach diagnostic support systems will only interact with the CPE at MD level 1. Any implementation of MD levels 2 and above in the CPE is therefore optional and outside the scope of R.OAM.8. See Section 2.1.8 for further information on OAM implementation.

Default settings are as follows:

- MD level: Level 1 for Openreach
- VID of MA: VLAN ID = 101
- MEP ID list of MA: MEP ID is not required for OAM loopback
- Direction of MEP on the WAN port must be down: The MEP should respond to LoopBack messages from the DSLAM direction, and responses should be sent back towards the DSLAM
- MEP ID of MEP on the WAN port: MEP ID is not required for OAM LoopBack
- MD Name format: MD Name & format is not required for OAM LoopBack
- MD Name: MD Name is not required for OAM LoopBack
- MA Name format: MA Name & format is not required for OAM LoopBack
- MA Name: MA Name is not required for OAM LoopBack
- CC interval: Only OAM LoopBack is supported at present, therefore CC interval not required

The modem must be able to respond to LBMs when passing customer traffic at the full downstream and upstream rates supported by the modem.

3.2.6 Filter Requirements

In order to ensure correct operation with Openreach's GEA-G.fast and PSTN networks, filter devices intended for connection to Openreach GEA-G.fast lines shall meet one of two alternative sets of recommendations.

R.FILTER.1 Centralised filters shall comply with the requirements of ETSI Specification TS 101 952-1 extended to 212 MHz as set out in Section 3.2.6.1

R.FILTER.2 Distributed filters shall comply with the following requirements of ETSI Specification TS 101 952-3 extended to 212 MHz as set out in Section 3.2.6.2 0.

3.2.6.1 Centralised Filters

Centralised filters shall comply with the following requirements of ETSI Specification TS 101 952-1 extended to 212 MHz:

I. Option B category of TS 101 952-1
II. The option to support metering pulses as described in Section 6.7 of TS 101 952-1 does NOT need to be implemented

III. The option to provide common mode rejection as described in Section 6.14 of TS 101 952-1 does not need to be implemented, although it is known that this option can help to improve service reliability

IV. The applicable tables in Normative Annex A of TS 101 952-1 for VDSL2 filters are:
    - Table A.2 (Dedicated requirements for splitters for xDSL system variants)
    - Table A.3 (Differentiation of IL in the xDSL band between LE and TE side)
    - Table A.6 (Dedicated frequency ranges for splitters for VDSL2 system variants)
    - Table A.9 (Dedicated requirements for passive splitters for VDSL2 over POTS variants at the TE side)

3.2.6.2 Distributed Filters

Distributed filters shall comply with the following requirements of ETSI Specification TS 101 952-3 extended to 212 MHz:

1. Option B category of TS 101 952-3
2. The option to support metering pulses as described in Section 6.7 of TS 101 952-3 does NOT need to be implemented
3. The applicable tables in Normative Annex A of TS 101 952-3 for VDSL2 filters are:
    - Table A.2 (Dedicated requirements for splitters for xDSL system variants)
    - Table A.3 (Overview of all POTS band requirements for all types of filters and N values)
    - Table A.6 (Overview of insertion loss in the xDSL band for all types of filters)
    - Table A.7 (Dedicated frequency ranges for distributed filters for VDSL system variants)

    Where appropriate the requirements for either the “Standard” filter class (see Section 6.1.1 of TS 101 952-3) with N=3 or the “Enhanced” filter class with N=4 shall be selected from the appropriate column in the tables (N is the minimal number of parallel filters in the test setup – see section 6.4.1 of TS 101 952-3)
4. If the CP filters are to be used in a multiple filter topology, the filter shall meet the requirements of TS 101 952-3 with up to two other CP filters (Standard) or three CP filters (Enhanced)

connected in parallel with the CP filter under test. Each filter shall have its Telephony Port open circuit.

3.2.6.3 Additional notes about CPE filters

The standard Openreach PSTN CPE interface is a 3 wire circuit (A-line, B-line and bell wire) whereby the bell wire is AC-coupled from the B-line. This bell wire must either be filtered by the filter or left open circuit at the Line Port and recreated at the Telephony Port of the filter. This may be achieved using a 1.8 μF capacitor between the B line (pin 5) and the bell wire (pin 4) at the Telephony Port.

It should be noted that during normal operation of Openreach PSTN services switching may occur between line states such as line feed, reversed line feed, ringing and dialling (loop disconnect or tone). These changes of state may be associated with large transient voltage excursions. The performance of data circuits operating from the G.fast Port under these conditions is a function of the data modem internal performance. This and other factors may be a cause for specifications outside the scope of this document.

The A-line and B-line may be disconnected, shorted together, taken to earth or connected to standard network conditions (Voltages up to -95 V, PSTN conditions, ringing etc.) at any point in the system. No maintenance intervention should be required after such an event to restore normal modem operation.

3.2.6.4 Supplementary Information

The CP shall ensure that the lead which is provided to connect the modem to the filter is of a sufficient quality not to compromise G.fast performance (e.g. a minimum of Category 5 UTP cable).

CPs considering the requirements of their network connectivity devices for the medium to long term future, may wish to consider the applicable General Conditions of Entitlement (see Note 1) for PATS and other services, in addition to other guidance documents such as Ofcom's "Guidelines on the use of battery back-up to protect lifeline services delivered using fibre optic technology" (see Note 2) when specifying their wider modem/router requirements. Should applicable regulation or guidance change, a revised version of this SIN may result.

NOTE 1: http://stakeholders.ofcom.org.uk/telecoms/ga-scheme/general-conditions/

NOTE 2: http://stakeholders.ofcom.org.uk/consultations/superfast-broadband/summary

4. References

[1]	SIN 360	Ethernet Customer Interfaces, Interface Characteristics.
[2]	BS EN 60950-1	Information technology equipment. Safety. General requirements. http://www.bsigroup.com
[3]	IEEE 802.3	Standards for Local Area Networks: CSMA/CD Access Method
[4]	BBF TR-101	Broadband Forum – Migration to Ethernet-Based DSL Aggregation
[5]	IEEE 802.1ad	Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges
[6]	IEEE 802.1D-2004	IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges
[7]	ITU-T G.9700	Fast access to subscriber terminals (G.fast) – Power spectral density specification
[8]	ITU-T G.9701	Fast Access to Subscriber Terminals (FAST) – Physical layer specification
[9]	SIN 498	Fibre to the Cabinet (FTTC) Generic Ethernet Access Service and Interface Description
[10]	SIN 503	Generic Ethernet Access Multicast, Service & Interface Description
[11]	ITU-T Y.1731	OAM functions and mechanisms for Ethernet based networks
[12]	ITU-T G.994.1	Handshake procedures for digital subscriber line transceivers
[13]	ITU-T G.997.2	Physical Layer Management for G.fast Transceivers
[14]	BBF IR-337	G.fast Certification Test Plan https://www.broadband-forum.org/projects/access-next/gfast
[15]	BBF TR-069	CPE WAN Management Protocol
[16]	SIN 351	BT Public Switched Telephone Network (PSTN): Technical Characteristics Of The Single Analogue Line Interface
[17]	NICC ND:1602	Specification of the Access Network Frequency Plan (ANFP) applicable to transmission systems used on the BT Access Network
[18]	ETSI TS 101 952-1	Access network xDSL splitters for European deployment; Part 1: Generic specification of xDSL over POTS splitters
[19]	ETSI TS 101 952-3	Access. Networks, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment;

		Part 3: Generic specification of static distributed filters for xDSL over POTS.
[20]	NICC ND:1030	Ethernet ALA Service Definition
[21]	STIN 517	Single Order Generic Ethernet Access (SOGEA), Service & Interface Description
[22]	BBF TR-177	Broadband Forum – IPv6 in the context of TR-101
[23]	ITU-T G.993.5	Self_FEXT cancellation (vectoring) for use with VDSL2 transceivers

Note: For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

5. Abbreviations

Abbreviation	Description
BRAS	Broadband Remote Access Server
CFPCG	Copper and Fibre Products Commercial Group
CP	Communications Provider
C-VLAN	Customer VLAN
DHCP	Dynamic Host Configuration Protocol
DLM	Dynamic Line Management
DSLAM	Digital Subscriber Line Access Multiplexer
DTH	Double Tagged Handover
EFM	Ethernet in the First Mile
EU	End-user
FC/PC	Fixed Connection – fibre optic connector
FE	Far End
FEC	Forward Error Correction
FEXT	Far End Crosstalk
FoD	Fibre on Demand
FRA	Fast Rate Adaptation
FTTC	Fibre To The Cabinet
FTU-R	Fast terminating Unit – remote (i.e. customer end device)
GEA	Generic Ethernet Access
IA	Intermediate Agent
IFG	Inter-Frame Gap
IGMP	Internet Gateway Managed Protocol
IP	Internet Protocol
L2S	Layer 2 Switch (with integrated OLT)
LACP	Link Aggregation Control Protocol
LAN	Local Area Network
LBM	Loopback Message
LC	Lucent Connector/Local Connector – fibre optic connector
MAC	Media Access Control
MD	Maintenance Domain
MDI/MDIX connection	Medium Independent interface (cross-over) – Ethernet port
NE	Near End

NTE5	Network Terminating Equipment #5. The point in the customer's premises where the Openreach network terminates.
NGA	Next Generation Access
NGA1	Superfast Broadband
NGA2 G.fast	Ultrafast Broadband
NT	Network Termination
NTR	Network Timing Reference
OAM	Operations, Administration, Maintenance
PADI	PPPoE Active Discovery Initiation
PADO	PPPoE Active Discovery Offer
PADS	PPPoE Active Discovery Session- confirmation
PCP	Priority Code Point aka 802.1p priority. See 0
PCP	Primary Cross-connect Point (aka cabinet)
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RJxx	Registered Jack – a standardised physical network connector
SC	Standard Connector – fibre optic connector
SIN	Suppliers' Information Note (Openreach publication)
SRA	Seamless Rate Adaptation
SSFP	Service Specific Face Plate
STB	Set-Top Box
STH	Single Tagged Handover
S-VLAN	Service VLAN
UNI	User Network Interface
UTP	Unscreened Twisted Pair
VDSL	Very high-speed Digital Subscriber Line
VDSL2	Second generation VDSL
VLAN	Virtual Local Area Network

6. History

Issue	**Date**	**Changes**

1	September 2019	First version of SIN.
1.1	April 2020	Change SINet site references from http://www.btplc.com/sinet/ to https://www.openreach.co.uk/orpg/home/helpandsupport/sins/sins.do
1.2	Aug 2021	Additions to Sections B.1.1, B.4.2.2.6, B.4.2.2.9, and B.4.2.2.2.10, plus minor editorials. Clarified the VLAN 0 capability of the Openreach G.fast modem
1.2	May 2022	Updated US priority marking in section 2.2.3
1.2	May 2023	Annual Review – branding and font changes only – issue remains unchanged.
1.2	October 2024	Annual Review – branding and font changes only – issue remains unchanged.

Annex A – Self- Certification of CP Provided Modems

The introduction of a self-certification option for CPs to use to test their G.fast modem/routers against, will enable CPs to test most of the requirements detailed in this SIN in their own environments, or that of their suppliers. CPs will be able to submit their devices to Openreach for a much shorter G.fast Modem Conformance test, after sharing the results of their self-certification testing with Openreach for verification.

It is hoped that introduction of this process will enable faster acceptance of devices onto the Openreach network, reducing costs and time to market for G.fast devices.

Table 8 shows which requirements can be verified by CPs and which would be verified by Openreach. Verification should be demonstrated using one of the Openreach G.fast flight cases (contact flightcase.bookings@openreach.co.uk for details).

A detailed description of the modem conformance test (MCT) requirements to enable a piece of vendor CPE to be validated against these requirements is contained in Annex B.

Requirement	**Description**	**Verification by**
R.PHY.1	Physical Connector	CP
R.FAST.1	BBF G.fast Certification	CP
R.FAST.2	Compliance with mandatory sections of G.9700 and G.9701	CP
R.FAST.3	Support of Profile 106a and 106b	CP
R.FAST.4	Compliance with Part F of the UK ANFP	Openreach
R.FAST.5	Support of AA43C handshake tones (i.e. A43 and A43 only)	Openreach
R.FAST.6	Compatibility with 17MHz VDSL2	Openreach
R.FAST.7	Aggregate 1Gbps capacity (2 to 106 MHz)	CP
R.FAST.8	Support of upstream and downstream retransmission	CP
R.FAST.9	Support of upstream and downstream vectoring	Openreach
R.FAST.10	Support of seamless rate adaptation (SRA) in both upstream and downstream directions	Openreach/ CP

R.FAST.11	Support of fast rate adaptation (FRA) in both upstream and downstream directions	Openreach
R.FAST.12	CPE noise floor ≤ -150 dBm/Hz	CP
R.FAST.13	Support of 8 dBm aggregate downstream transmit power	CP
R.FAST.14	Support of 8 dBm aggregate upstream transmit power	CP
R.FAST.15	Capable of transmitting at PSDs of up to -65 dBm/Hz at frequencies up to 30 MHz.	Openreach
R.FAST.16	Support of TDD frame lengths of 36 symbol periods	CP
R.FAST.17	Correct reporting of Hlog	Openreach
R.FAST.18	Correct reporting of QLN	Openreach
R.FAST.19	Correct reporting of ALN	Openreach
R.FAST.20	Support of low power modes	CP
R.FAST.21	Correct inventory reporting	Openreach
R.FAST.22	Support of up to 14bits/tone in both upstream and downstream directions	CP
R.FAST.23	Correct reporting of performance data	Openreach
R.FAST.24	Support of RFI and ARI notching	Openreach
R.FAST.25	Support of upstream power back-off (UPBO)	Openreach
R.FAST.26	Correct reporting of vendor information	Openreach
R.FAST.27	Support of bit swap	CP
R.FAST.28	Support of sub-carrier masking (aka tone blackout)	CP
R.FAST.29	Support of Minimum ANDEFTR	CP
R.FAST.30	Support of Maximum ANDEFTR	CP
R.FAST.31	Support of Sum ANDEFTR	CP
R.FAST.32	Support of ANDEFTRDS counter	CP
R.FAST.33	Support of LANDEFTRS counter	CP
R.FAST.34	Support of LANDEFTR defect threshold	CP
R.ETH.1	Support of an Ethernet frame size of between 68 and 1534 bytes.	CP

R.WAN.1	Withdrawn	
R.WAN.2	Support of encapsulation within an IEEE 802.1q VLAN (C-VLAN)	CP
R.WAN.3	Support of Multicast and Unicast over the same single-tagged VLAN.	CP
R.WAN.4	Ethertype (Tag Protocol Identifier) field of the Ethernet frame set to 0x8100	CP
R.WAN.5	CVLAN Canonical Format Indicator set to zero	CP
R.WAN.6	VLAN ID set to 101 for when GEA Data and Multicast are used	CP
R.WAN.7	IGMP reports encoded as IGMPv3 or IGMPv2 over CVLAN ID 101	Openreach
R.WAN.8	Multicast for GEA frames not encapsulated with PPP	Openreach
R.OAM.1	Support of "dying gasp"	Openreach
R.OAM.2	EFM OAM permanently enabled	CP
R.OAM.3	EFM OAM loopback	Openreach
R.OAM.4	EFM OAM loopback traffic on VLAN 101	CP
R.OAM.5	EFM OAM statistics collection	Openreach
R.OAM.6	RX and TX statistics collection point	CP
R.OAM.7	EFM OAM statistics response format	CP
R.OAM.8	Support for Y.1731 Loopback Messages	Openreach
R.FILTER.1 / R.FILTER.2	Compliance to ETSI TS 101 952 Part 1 (extended to 212 MHz) or Part 3 (extended to 212 MHz)	CP

Table 8 : Test Requirement Verification

Annex B – Test Requirements for GEA-G.fast CPE

This Annex provides a detailed breakdown of the modem conformance test (MCT) requirements to enable a piece of vendor CPE to be validated against the Requirements defined in Section 3 of this document. These are largely based on the requirements of BBF IR-337 0 except that it refers to Openreach specific profiles, cable types, lengths and gauges and also limits the G.fast spectrum from 18.32 to 106 MHz.

Details on how to engage with Openreach on Modem Conformance Testing may be obtained by contacting our Service Establishment team at:
customer.establishment@openreach.co.uk.

B.1 Test Configuration

B.1.1 Line Profile

The following default G.fast Line Profile ULR_MAX_2_MAX_2_3_3_1 shall be used for all tests unless otherwise specified, i.e. R.FAST.27 (Bit Swap Test).

This default Line Profile differs from the configuration parameters defined in IR-337 0 which have been derived from G.997.2 0 to reflect the specific service deployment of G.fast in the Openreach network.

Unless specified otherwise for an individual test case, the G.fast configuration parameter values defined in this section SHALL be used.

Parameters for the Test Default Band Line Profile are defined in Table 9.

ULR_MAX_2_MAX_2_3_3_1		
Parameter	Downstream Setting	Upstream Setting
Operating Mode	G.9701	
Maximum Data Rate	2,000,000 kbit/s	2,000,000 kbit/s
Minimum Data Rate	2,000 kbit/s	2,000 kbit/s
Minimum Noise Margin	0 dB	0 dB
Target Noise Margin	3 dB	3 dB
Maximum Noise Margin	31 dB	31 dB
Adaption mode	During Showtime	During Showtime
Retransmission	Low (Note 1)	Low (Note 1)
UPBO	n/a	Enabled (Note 2)
TDD	83 (29 symbols)	17 (6 symbols)
IAR/RFI Notching	Disabled	Disabled
Note 1 - High or Low retransmission values are available		
Note 2 - The actual parameter value will vary between both DSLAM vendors		

Table 9 G.fast GEA Test Default Band Profile Definition

Note: Due to the deployment of DSLAMS at the PCP in side pods, the handshake signal needs to be modified to prevent adverse interference to other xDSL services running through a particular cabinet and shaped to comply with the UK ANFP Part B [17]

For the purpose of testing an ESEL of 30dB will be defined, except for; B.4.2.2.4 Support of Cabinet-based G.fast Operation (R.FAST.5)

B.1.2 Loops

CW1326 0.5mm Cu shall be used for all tests, which is the same cable that is used in the Openreach network.

Note that the Broadband Forum (BBF) IR-337 currently defines CAD55/CW1420 or simulated cable for all tests.

B.2 Network Equipment

Currently Openreach uses network equipment from two strategic vendors (namely Huawei and Nokia) in its G.fast GEA FTTC network. This means that any CP provided modem must be able to operate across a variety of DSLAM chassis types and line cards.

The test procedures described in this document shall be performed using the current firmware versions of network equipment deployed in the Openreach G.fast FTTC GEA network unless otherwise stated.

B.3 Test Equipment

The test equipment used by Openreach to perform these tests is shown in Table 10. Other equivalent equipment may be substituted.

Test Equipment	Example
High Frequency Balun (1MHz – 650MHz)	BH Electronics
Noise Generator/Injector	Spirent DSL5900 / ACC5901
Power Splitter	Keysight 11667L
Spectrum Analyser	Rhode and Schwartz FSV3
Oscilloscope	Rhode and Schwartz RTO1012
Impedance Matching network	Custom Built (see Figure 15)
Balun (Low Frequency) 1kHz-20MHz	North Hills 0311LB

Table 10 Openreach GEA Test Equipment

B.3.1 Details of Impedance Matching Network

In order to measure the transmit power spectral density (PSD) of the G.fast system under test an impedance matching network (aka Loss Pad) is needed to correct the impedance of the simulated loop to as close as possible to the 100 Ohm reference impedance. Such a matching network is shown in Figure 13

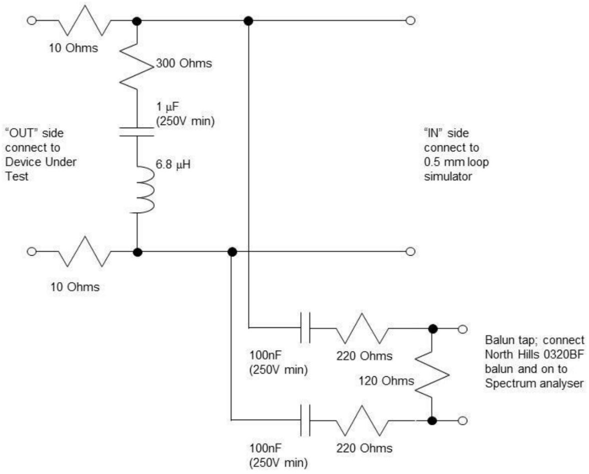

10 Ohms
300 Ohms
1 µF
(250V min)
"OUT" side
connect to
Device Under
Test
6.8 µH
"IN" side
connect to
0.5 mm loop
simulator
10 Ohms
100nF
(250V min)
220 Ohms
120 Ohms
Balun tap; connect
North Hills 0320BF
balun and on to
Spectrum analyser
100nF
(250V min)
220 Ohms

Figure 15 PSD matching pad and balun tap

The output of the balun tap for this matching network has a loss from the device under test of 20.7 dB, and in addition a further 0.4 dB loss must be allowed for the balun. The loss of this path must be taken into account when calculating the PSD.

B.4 Modem Conformance Test (MCT) Requirement for GEA

The MCT requirements for GEA are split into the following three sections:

- Initial Gating
- Compliance with Section 3 of SIN 527
- GEA Testing

The details of the various tests are defined in the following paragraphs

B.4.1 Initial Gating Tests

The purpose of these tests is to check that the CPE modem can synchronise with a GEA field configuration and will not cause network harm. It is necessary for a CPE to "Pass" both of these tests before full SIN 527 conformance testing can commence. If either of these tests results in a "Fail", the CPE vendor will be informed by Openreach and asked to resolve the issue.

B.4.1.1 Synchronisation and Passive mode check

Description – The modem shall achieve synchronisation to a reference G.fast GEA DSLAM, and be configured in Passive mode in order to maintain a permanent OAM session with the Active DPU.

Test Procedure – Connect modem to a port on the DSLAM via a back to back connection (i.e. 0 m loop length) and ensure that it trains up and reaches synchronisation.

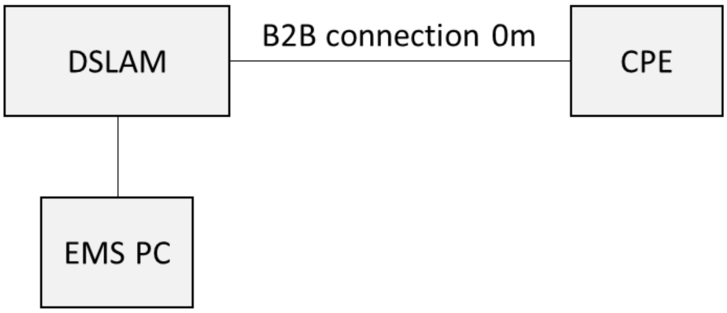


Figure 16 Test Configuration for Checking Basic Synchronisation

1. Configure DSLAM to implement an ESEL value of 30 dB and ensure that the default band profile is loaded onto a port.
2. Connect the CPE modem to the DSLAM port and check that it reaches synchronisation within 90 seconds.
3. If synchronisation is attained, check that the modem stays in synchronisation for a minimum of 120 seconds.
4. Check that Passive mode is set on the CPE modem via the EMS

Expected Outcome – This test will be deemed a "Pass" if the modem attains synchronisation within 90 seconds, stays trained up for a minimum of 120 seconds and Passive mode can be confirmed, else the test will be deemed a "Fail". This test also verifies that the physical layer interface on the CPE modem is wired correctly (Requirement R.PHY.1).

B.4.1.2 Network Interference

Description – The modem shall not cause adverse interference to other systems operating in the same cable binder. In order to validate this, the modem shall only implement the A43 or A43c tone sets defined in G.994.10, demonstrate that it does not cause adverse interference to other lines operating in a vectored group and comply with the requirements of Part F of the Access Network Frequency Plan0

Test Procedure – Measure upstream PSD on two different line lengths (100 m, and 300 m) to check that system complies with Part F of the ANFP and that upstream transmit power does not exceed that defined for Profile 106b (G.97010)

1. Configure DSLAM to implement an ESEL value of 30 dB and configure a port with the default band profile.
2. Connect the DSLAM and the CPE using the Test Configuration shown in Figure 17. to a single 100 m 0.5 mm Cu pair (i.e. noise free)
3. During train-up, capture the handshake tones generated by each end of the transmission system.

4. Compare tones against those defined for A43 and A43c to check that tones other than A43/A43c are NOT being used.
5. Once the CPE has attained synchronisation, capture upstream PSD and wideband power and compare against Part F of the ANFP.
6. Repeat for both a warm-start and a cold-start[†].
7. Repeat for 300m loop length.

Note that this test also covers requirements R.FAST.4 (Compliance with Part F of the ANFP), R.FAST.25 (Support of UPBO) and the upstream part of R.FAST.5 (Support of Cabinet Based Operation).

In addition, it is also necessary to verify that the CPE modem does not cause adverse interference to a GEA system implementing vectoring. The details for this test are defined in Section B.4.2.2.7 (Support of vectoring - R.FAST.9).

Expected Outcome - If the upstream transmit spectrum complies with the spectrum limits defined in Part F of the ANFP over the various loop lengths tested, the upstream transmit power does not exceed 8 dBm, only tone-sets A43 and A43C are used, and the CPE is shown not to have an adverse impact on the performance of a vectored group then this will be deemed a "Pass", else the result will be a "Fail".

B.4.2 SIN 527 Modem Conformance Tests

See Section 3 for details of the specific requirements to which these conformance tests refer.

B.4.2.1 Physical Layer Tests

Each of the following sections defines the test required to demonstrate compliance to a particular requirement of SIN 527. The requirement number is shown in brackets after the title of the test.

B.4.2.1.1. Physical Connection (R.PHY.1)

Description - The socket on the CPE modem connecting to the Openreach UNI (i.e. WAN port) shall be either a RJ11 or RJ45 type to enable it to be connected to the VDSL2 filter using standard leads. The VDSL2 connection is presented on the middle two pins - i.e. pins 3&4 (RJ11) or pins 4&5 (RJ45). The other pins are not connected. Pin numbering is from the left, looking into the socket with the contacts uppermost. Polarity is unimportant.

[†] *A warm-start is when the modem is disconnected from the line but remains powered up. Resynchronisation occurs when the modem is reconnected to the line. A cold-start is when the modem is powered off and then powered back on again remaining connected to the line (i.e. a full restart).*

Test Procedure – Visual inspection.

Expected Outcome – The basic synchronisation and network interference tests will confirm whether the DSL socket on the CPE modem has been wired correctly (see B.4.1).

B.4.2.2 G.fast Layer

B.4.2.2.1. Support of Mandatory Requirements of G.9700 and G.9701 (R.FAST.2)

Description – The CPE modem used shall fully comply with the G.fast mandatory requirements of G.9700 0, and G.9701 0.

Test Procedure – Vendor derived, in line with G.9700 and G.9701. Copy to be provided to Openreach on request.

Expected Outcome – Vendor to confirm (in writing) via the Modem Conformance Test Request form, that their modem complies with the mandatory requirements of G.9700 and G.9701.

B.4.2.2.2. Support of Profile 106 (R.FAST.3 and R.FAST.7)

Description – The Modem shall support 2-106 MHz operation using profile 106a or 106b as defined in G.9701 0. The Modem shall comply with the requirements of Part E of the Access Network Frequency Plan [17]

Test Procedure – Measure downstream PSD on short line (100 m) to check that 18.32-106 MHz bandwidth is being utilised and that downstream transmit power does not exceed that defined for Profile 106a or 106b.

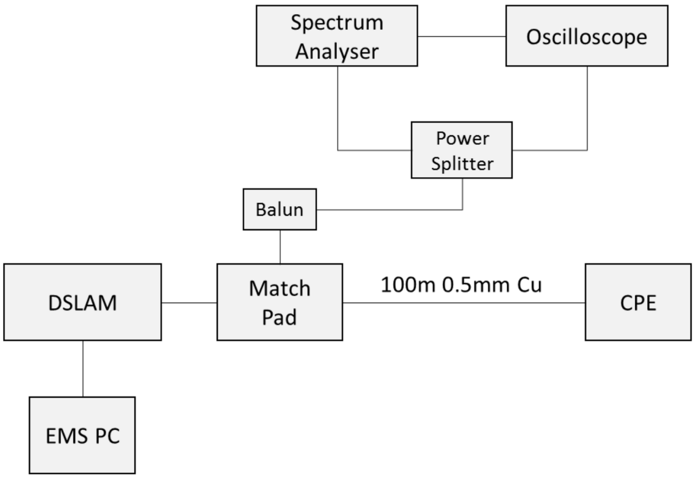


Figure 17 Test Configuration for Measuring Downstream PSD

Note: Details of the impedance matching pad used are shown in Figure 13

1. Configure DSLAM to implement an E-side electrical length (ESEL) value of 30 dB and configure a port with the default band profile.
2. Set to a single loop length of 100 m.
3. Connect CPE to DSLAM using the Test Configuration shown in Figure 15.

4. Ensure that CPE has attained synchronisation.
5. Capture downstream PSD and wideband power and compare against Part E of the ANFP 0.

Repeat test for a single loop length of 300m.

Expected Outcome – This test will be deemed a "Pass" if the use of downstream band spectrum complies with the spectrum limits defined in Part E of the ANFP between 18.32 and 106 MHz, and that the downstream transmit power does not exceed that defined for Profile 106a or 106b. If these criteria are not met, then the result is a "Fail".

B.4.2.2.3. Compliance with ANFP Part F (R.FAST.25)

Description – The Modem shall comply with the requirements of Part F of the Access Network Frequency Plan 0.

Test Procedure – Measure upstream PSD on two different line lengths (100 m, and 300 m) to check that system complies with Part F of the ANFP and that upstream transmit power does not exceed that defined for Profile 106b

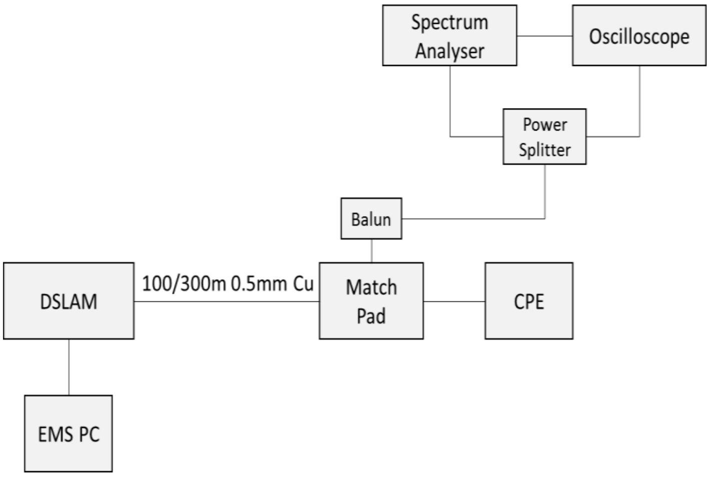


Figure 18 Test Configuration for Measuring Upstream PSD

Note: Details of the impedance matching pad used are shown in Figure 13

1. Configure DSLAM to implement an ESEL value of 30 dB and the default band profile.
2. Connect CPE to DSLAM using the Test Configuration shown in Figure 16.
3. Set to a single loop length of 100 m.
4. Ensure that CPE has attained synchronisation.
5. Capture upstream PSD and wideband power and compare against Part F of the ANFP.

Repeat for 300 m loop length.

Expected Outcome - If the upstream transmit spectrum complies with the spectrum limits defined in Part F of the ANFP over the various loop lengths tested and the total upstream transmit power measured does not exceed that defined for Profile 106a or 106b then this will be deemed a “Pass”, else the result will be a “Fail”.

B.4.2.2.4. Support of Cabinet-based G.fast Operation (R.FAST.5)

Description – The Modem shall support operating with cabinet-based G.fast. This requires the support of tone-sets (or carrier sets) A43 and A43C (as defined in G.994.1 Amendment 1 0 and shown in Table 11), plus downstream PSD shaping and upstream power back-off as defined in G.9701 0 and G.994.1 0. In order to achieve synchronisation, the modem must also support these tone-sets.

Carrier Set Designation	Upstream Carrier Sets		Downstream Carrier Sets	
	Tone Numbers	Maximum power level/carrier (dBm)	Tone Numbers	Maximum power level/carrier (dBm)
A43	9 17 25	-1.65	40 56 64	-3.65
A43c	9 17 25	-1.65	257 293 337	-3.65

Table 11 Carrier Sets A43 and A43c

Note that use of additional tone-sets (B43, B43c, V43 etc.) is not permitted as these may cause the spectral limits defined in Parts B and C of the ANFP to be breached, resulting in adverse interference to other DSL systems operating in the same cable binder.

Test Procedure – Measure CPE handshake tone sets on two different line lengths (100 and 300m) to check that CPE conforms with Part C of the ANFP.

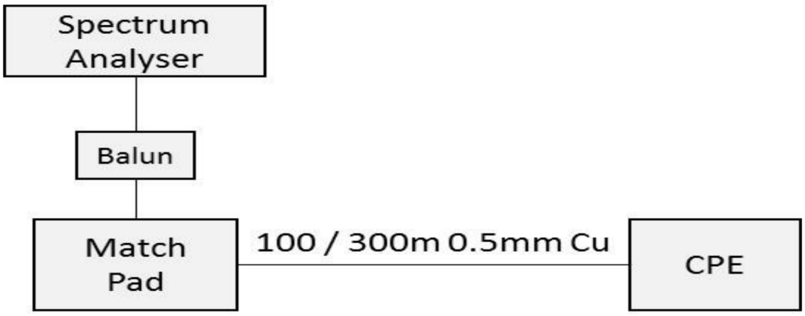


Figure 19: Test configuration for CPE handshake captures

Note: 1 kHz – 20 MHz North Hills Balun used for this test

1. Set spectrum analyser for a start frequency of 10 kHz and a stop frequency of 5 MHz.
2. Configure DSLAM to implement an E-side electrical length (ESEL) value of 30 dB and the default band profile.
3. Connect CPE to DSLAM using the Test Configuration shown in Figure 17.
4. Set to a single loop length of 100 m

5. During train-up, capture the handshake tones generated by each end of the transmission system.
6. Compare tones against those defined for A43 and A43c.
7. Plot captured downstream tones against ANFP Part C spectral limit to check that PSD shaping has been applied to the tones and that tones other than A43/A43c are NOT being used.
8. Repeat on a cold-start, and at 300m

Repeat for a minimum of two other ESEL values (nominally 16 and 52 dB)

Expected Outcome - This test will be deemed a "Pass" only if A43/A43c tone sets are being used and that the correct amount of PSD shaping is being applied to the tone to ensure compliance with the appropriate limit masks defined in Part C of the ANFP for each value of ESEL evaluated and for both a warm-start and a cold-start. If these criteria are not met, then the result is a "Fail".

B.4.2.2.5. Support of UPBO (R.FAST.25)

Description – The Modem shall support Upstream Power Back Off (UPBO) as defined in G.9701.

Test Procedure – See Section B.4.2.2.3 "Compliance with ANFP Part F (R.FAST.4)".

Expected Outcome - If the upstream transmit spectrum complies with Part F of the ANFP over the various loop lengths tested then this will be deemed a "Pass" as this requires UPBO to be implemented correctly, else the result will be a "Fail".

B.4.2.2.6. Support of Seamless Rate Adaption (R.FAST.10)

Description – The Modem shall support seamless rate adaptation (SRA) as defined in Section 13.2.1.1 of G.9701 0.

Test Procedure – Configure system to operate in the presence of flat noise (120MHz bandwidth -120 dBm/Hz), reduce level of noise at each end and then check whether SRA is implemented. Note that SRA parameters defined are shown in Table 12.

Parameter	**Downstream**	**Upstream**
Minimum upshift time (s)	30	30
Minimum downshift time (s)	1	1

Upper threshold margin (dB)	4	4
Lower threshold margin (dB)	2	2

Table 12 Settings for Seamless Rate Adaption Profile

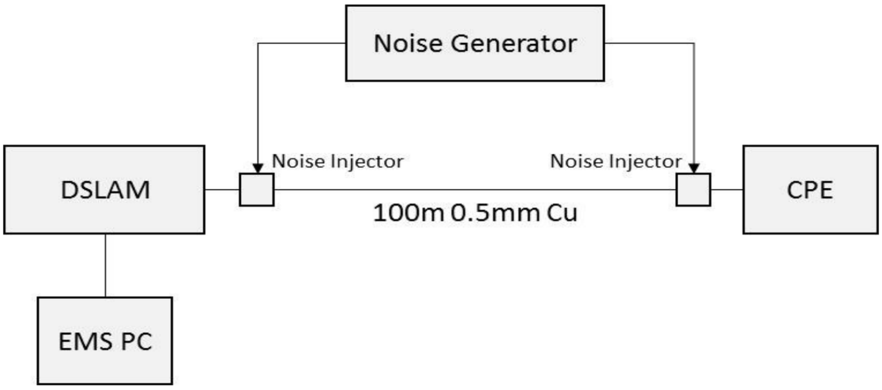


Figure 20 Test Configuration for Checking Seamless Rate Adaption

1. Configure DSLAM to implement an ESEL value of 30 dB.
2. Connect CPE to DSLAM using the Test Configuration shown in Figure 18.
3. Set to a single loop length of 100m with noise injected at each end of the system.
4. Ensure that CPE has attained synchronisation.
5. Record upstream and downstream margin and data rates as reported by the DSLAM.
6. Using Noise Generator increase noise in 1dB steps every 10 seconds, to a maximum of 6 increases (i.e. 6dB increase).
7. After approximately 20 seconds record upstream and downstream margin and data rates as reported by the DSLAM.
8. Decrease noise in 2dB steps every 10 seconds, back to starting point.
9. After approximately 20 seconds record upstream and downstream margin and data rates as reported by the DSLAM.
10. Decrease noise in 1dB steps every 16 seconds, to a maximum of 6 decreases (i.e. 6dB decrease).
11. After approximately 20 seconds record upstream and downstream margin and data rates as reported by the DSLAM.
12. The CPE should not lose synchronisation during this test.

Expected Outcome – This test will be a “Pass” if the DUT is found to increase and decrease data rate in each direction, when the external noise increases and decreases slowly over time by 6dB without losing synchronisation. If the rate does not change in either direction or if the DUT retrains, then the result will be a “Fail”.

B.4.2.2.7.Support of FRA (R.FAST.11)

Description – The Modem shall support fast rate adaptation (FRA) as defined in Section 13.3.1.1 of G.9701 0.

Test Procedure – Configure system to operate in the presence of flat noise (120MHz bandwidth -120dBm/Hz), reduce level of noise at each end and then check whether SRA is implemented. Note that FRA parameters defined are shown in Table 13.

Parameter	**Downstream**	**Upstream**
Time Window Duration (s)	8	8
Minimum Tone Threshold (%)	50	50
Minimum Uncorrectable DTUs Threshold	150	150
Vendor Discretionary Trigger Mechanism	Disabled	Disabled

Table 13 Settings for Fast Rate Adaption Profile

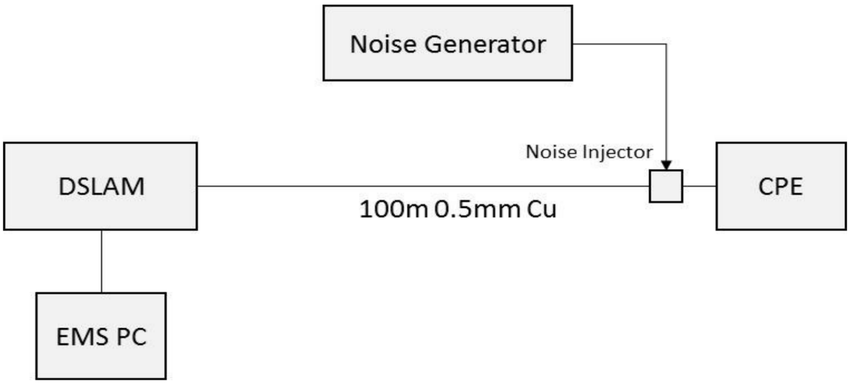


Figure 21 Test Configuration for Checking Fast Rate Adaption

1. Configure DSLAM to implement an ESEL value of 30 dB.
2. Connect CPE to DSLAM using the test configuration shown in Figure 19.
3. Set to a single loop length of 100m with noise injected at CPE end of the system.
4. Ensure CPE has attained synchronisation.
5. Record FRA (and SRA) events and rates as reported by the DSLAM.
6. Reduce noise instantaneously by 12 dB, wait 60 seconds. After a 12 dB reduction in noise (i.e. a 12 dB improvement in margin), the data rate should change.
7. Record FRA (and SRA) events and rates as reported by the DSLAM.

8. Increase noise instantaneously by 12 dB (back to initial noise level), wait 60 seconds. After a 12 dB increase in noise (i.e. a 12 dB reduction in margin), the FRA threshold values will be exceeded and the data rate should reduce.
9. Record FRA (and SRA) events as reported by the DSLAM.
10. The CPE should not lose synchronisation during the test.

B.4.2.2.8.Support of Vectoring (R.FAST.9)

Description – The Modem shall support Vectoring as defined in G.993.5 0. This requires the Modem to be "vector ready".

Test Procedure - The test configuration used is shown in Figure 20. **Note**: This assumes the inclusion of at least one device under test per loop length (i.e. 8 devices), however this number could be less.

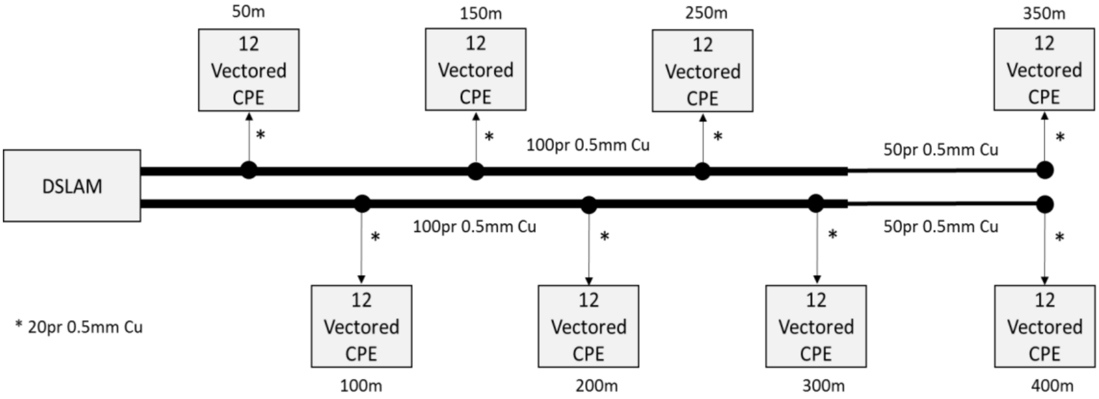

50m
12 Vectored CPE
150m
12 Vectored CPE
250m
12 Vectored CPE
350m
12 Vectored CPE
DSLAM
100pr 0.5mm Cu
50pr 0.5mm Cu
100pr 0.5mm Cu
50pr 0.5mm Cu
* 20pr 0.5mm Cu
12 Vectored CPE
100m
12 Vectored CPE
200m
12 Vectored CPE
300m
12 Vectored CPE
400m

Figure 22 Test Configuration for testing Vectoring Efficiency and Stability

From this it can be seen that the vectoring test configuration comprises eight lengths (50 m, 100 m, 150 m, 200 m, 250 m, 300 m, 350 m, 400 m) and recreates the typical root and branch topology of the Openreach copper access network. A 100pr 0.5 mm Cu cable, reduces to 50m culminating in a total length of 400 m, and at the various loop lengths branch of on to 20pr 0.5 mm Cu cable.

In this set-up there are a total of 96 vectored CPE, 12 located on each of eight different loop lengths from the DSLAM. The same cable segments are used to construct the 200 m, 500 m and 900 m lengths.

Note that these lengths are intended to be representative rather than prescriptive – other lengths can be used.

1. Place eight of the CPE under test on each of the eight loop lengths. Capture the single line performance data for each of the 96 modems. This enables the performance to be benchmarked.

2. Capture the vectored line performance data off all the CPE active in a vectored group. Compare the results obtained using the CPE at each cable length against those obtained using the 88 Openreach provided CPE. Note whether the CPE under test supports vectoring and whether there is any significant drop in performance either to the modem or the rest of the vector group when vectoring is enabled.

Expected Outcome – “Pass” if modem is capable of supporting vectoring and does not adversely affect the performance of the vector group, “Fail” if not.

B.4.2.2.9. Vectoring Stability (Inc. Joins and Leaves) (R.FAST.9)

Description –The Modem shall support Vectoring as defined in G.993.5 0. This test confirms the stability of the modems within a vector group when the DUT on adjacent circuits joins and leaves.

Note: This test is followed on after the Vectroing Efficiency and Stability test.

Test Procedure (Single Port) - The Test Configuration shown in Figure 20 shall be used for this test.

1. Record INITs data from DSLAM
2. Select DUT (preferably one connected to a 300m loop) and disconnect DSL RJ11 lead.
3. Leave lead disconnected for approximately 1 minute.
4. Reconnect DSL RJ11 lead and record time.for modem to achieve sync.
5. Record INITs data from DSLAM.

Test Procedure (Line Card Removal) – The Test Configuration shown in Figure 20 shall be used for this test.

1. Record INITs data from DSLAM
2. Remove Line Card from DSLAM chassis (Preferably 300 / 400m loops)
3. Leave Line Card removed for approximately 1 minute.
4. Re-insert Line card and record time taken for all devices on Line Card to achieve sync.
5. Record INIT's data from DSLAM.

Expected Outcome – "Pass" if no retrains are observed on adjacent devices, other than the modem under test leaving or joining a vectored group, either via a DSL lead pull or Line Card removal.

B.4.2.2.10. Support of Bitswap (R.FAST 27)

Description – The Modem shall support bit swap as defined in G.9701 0.

Test Procedure – Configure system to operate in the presence of Band-limited noise.

Note: This will require a dedicated profile as outlined by the Broadband Forum which has modified SRA configuration profiles.
The dedicated Bit Swap profile defines the following parameters:

BITSWAP_GFA_20_2_18_2_3_3_1		
Parameter	Downstream Setting	Upstream Setting
Operating Mode	G.9701	
Maximum Data Rate	330,000 kbit/s	50,000 kbit/s

Minimum Data Rate	2,000 kbit/s	2,000 kbit/s
Minimum Noise Margin	0 dB	0 dB
Target Noise Margin	3 dB	3 dB
Maximum Noise Margin	31 dB	31 dB
Downstream minimum time interval for upshift SRA (SRA-UTIMEds / SRA-UTIMEus)	16383 seconds	16383 seconds
Downstream minimum time interval for downshift SRA (SRA-DTIMEds / SRA-DTIMEds)	16383 seconds	16383 seconds
Adaption mode	During Showtime	During Showtime
Retransmission	Low (Note 1)	Low (Note 1)
UPBO	n/a	Enabled (Note 2)
TDD	83 (29 symbols)	17 (6 symbols)
IAR/RFI Notching	Disabled	Disabled
Note 1 - High or Low retransmission values are available		
Note 2 - The actual parameter value will vary between both DSLAM vendors		

Table 14: G.fast GEA Bit Swap Profile Definition

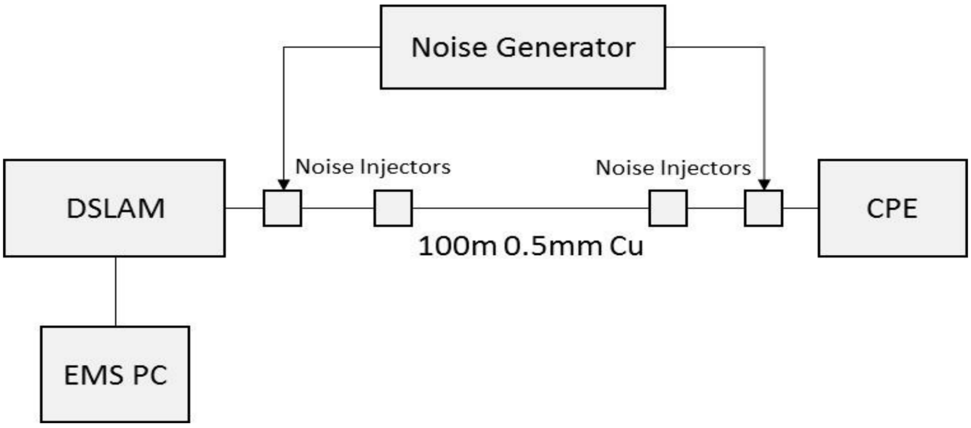


Figure 231 Test Configuration for Checking Bit Swap

1. Configure DSLAM to implement an ESEL value of 30 dB and the default band profile.
2. Connect CPE to DSLAM using the Test Configuration shown in Figure 21.
3. Set to a single loop length of 100m, start Band Limited Noise Type 1, -115 dBm/Hz for 50 MHz <f ≤ 60 MHz (noise band 1), -125 dBm/Hz for 70 MHz <f ≤ 80 MHz (noise band 2) injected at each end of the system.

4. Connect CPE (record time taken to achieve ShowTime) wait 60 seconds.
5. Capture bit allocation table data (upstream and downstream) from element manager.
6. Stop Band Limited Noise Type 1.
7. Start Band Limited Noise Type 2, -125 dBm/Hz for 50 MHz <f ≤ 60 MHz (noise band 1), -115 dBm/Hz for 70 MHz <f ≤ 80 MHz (noise band 2), wait 60 seconds.
8. Recapture bit allocation table data (upstream and downstream) from element manager..
9. Stop Band Limited Noise Type 2.
10. Start Band Limited Noise Type 1, wait 60 seconds.
11. Capture bit allocation table data (upstream and downstream) from element manager.
12. The bit allocation table should reveal an increase in the bit allocation at 50-60 MHz, and a reduction in the bit allocation at 70-80 MHz, on swap to Band Limited Type 2 Noise from Band Limited Noise Type 1.
13. The bit allocation table should reveal a decrease in the bit allocation at 70-80 MHz, and a increase in the bit allocation at 50-60 MHz when swapping back from Band Limited Noise Type 2 to Band Limited Noise Type 1.
14. The system should not retrain during this test.

Expected Outcome – “Pass” if bit swap is observed in the upstream and downstream bit allocation tables around the frequency of the interfering tone and modem does not lose synchronisation, else “Fail”.

B.4.2.2.11. Correct Reporting of Vendor Information (R.FAST.26)

Description – The Modem shall support the correct reporting of Vendor ID, Version Number and Serial Number as described in section G.997.2 0. In addition, non-printable ASCII characters (e.g. CR, LF, FF), delete (DEL) and comma (,) shall not be used.

Test Procedure – The CP shall provide the information shown in Table 15 and Table 16 to Openreach prior to the start of any testing. This will be as part of the Openreach Customer Establishment Process – details can be found at: http://www.openreach.co.uk/

CPE Manufacturer
CPE Product Name/Model

CPE Software Release Number
CPE Serial Number
System Vendor ID
Chipset Manufacturer
Chipset Hardware Version
Chipset Firmware Version

Table 15 CPE Information

Splitter Manufacturer
Product Name/Model
CPE Software Release Number
Version Number
Serial Number
Type (Centralised/Distributed)

Table 16 CPE Splitter Information

The element manager on the DSLAM will be used to validate the CPE Information. This should reflect the information provided in Table 15. CPE splitter information will be verified visually if possible against the information provided in Table 16.

Expected Outcome – If the reported data matches the information provided in Table 15 and no non-printable ASCII characters or commas are used, then this will be deemed a "Pass", else the CPE will be deemed to have failed the test.

B.4.2.2.12. Verification of Hlog and QLN (R.FAST.17 and R.FAST.18)

Description – This test is defined to test whether a CPE interworks with the G.fast GEA DSLAMs sufficiently well to report Hlog and QLN back to the DSLAM in a deployment scenario.

Test Procedure –

1. Set to a single loop length of 100 m
2. Connect the Network Analyser and Spectrum Analyser as shown in Figure 22 and Figure 23 and capture the reference Hlog and QLN spectrum on the line. This will form the Hlog and QLN templates used for this test.
3. Configure the DSLAM to implement an ESEL value of 30 dB
4. Connect the test setup as shown in Figure 24 and capture the Hlog and QLN data from the DSLAM element manager.

Repeat for the 300 m loop length.

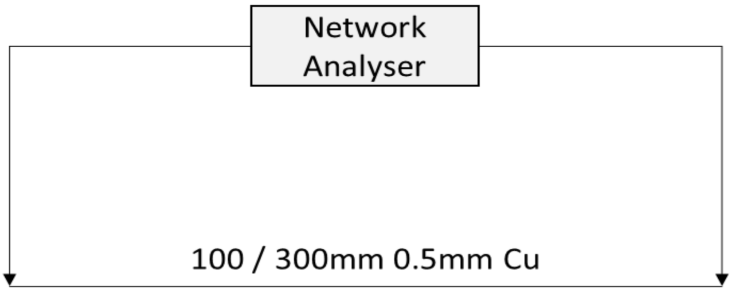


Figure 24 Configuration for Hlog Reference

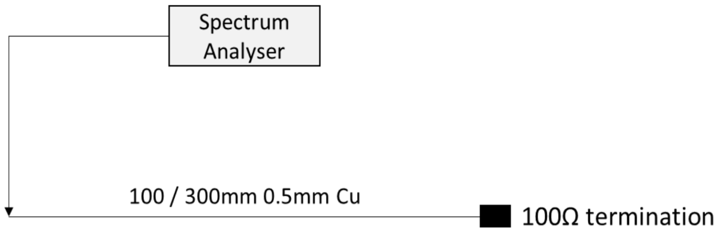


Figure 25 Configuration for QLN Reference

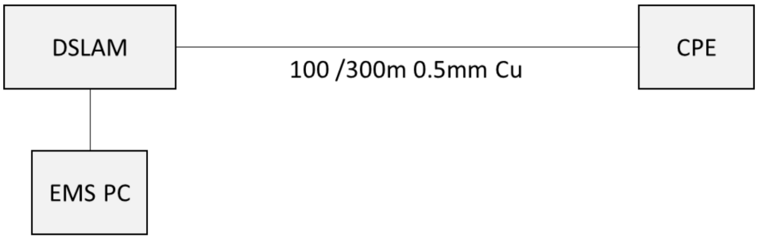


Figure 26 Test Configuration for Hlog / QLN test

Expected Outcome - The Hlog test will be deemed a “Pass” if the Hlog falls within a mask of +/- 3.5dB of the reference result of IL measured at 24 MHz in Figure 22. The QLN test will be deemed a “Pass” if the upstream and downstream QLN data falls within a range of +/-3.5dB of the reference value captured in Figure 23.

B.4.2.2.13. Notching (R.FAST.24)

Description - CP Modems shall support RFI and IAR (International Amateur Radio) notching as defined in G.9700, clauses 6.5 and 7.2.1 and G.9701, clause 7.3.1.2

Note that this will require a dedicated profile which is basically the same as the default test profile but with notching enabled. The additional parameters are shown in Table 17.

IAR Bit Representation	Band Start (kHz)	Band Stop (kHz)
6	21 000	21 450
7	24 890	24 990
8	28 000	29 700
9	50 000	54 000
10	70 000	70 500
FM Representation	**Start Tone**	**Stop Tone**

	1160 (60 MHz)	1256 (65 MHz)

Table 17 Settings for Notching Profile

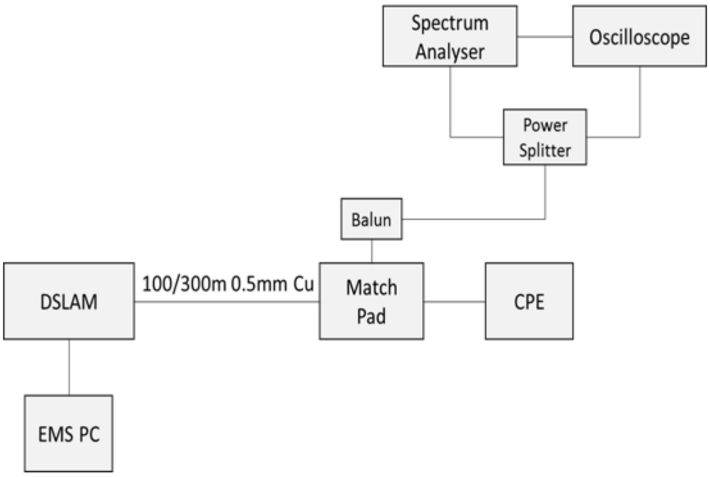


Figure 27 Test Configuration for notching test

Details of the impedance matching pad used are shown in Figure 13.

Test Procedure –

1. Configure DSLAM to implement an ESEL value of 30 dB and the notching band profile.
2. Connect CPE to DSLAM using the Test Configuration shown in Figure 25.
3. Set to a single loop length of 100 m.
4. Ensure that CPE has attained synchronisation.
5. Capture upstream PSD and wideband power and compare against Part E and F of the ANFP.

Repeat for 300 m loop length.

Expected Outcome – This test will be deemed a “Pass” if the notches are observed (i.e. subcarriers turned off and the notch shall be equal to the Limit PSD mask (LPM) -20 dB). If the notches are not seen then the result is a “Fail”.

B.4.2.2.14. Aggregate Bandwidth >800Mbit/s (R.FAST.7)

Description - CP modems shall be capable of supporting an aggregate (i.e. upstream plus downstream) bandwidth of 1 Gbit/s for 2 to 106 MHz operation.

Note that the 800 Mbit/s takes into account that Openreach use 18.32 MHz – 106 MHz, which reduces the aggregate bandwidth achievable.

1. Configure DSLAM to implement an ESEL value of 30 dB and ensure that the default band profile is loaded onto a port.
2. Connect the CPE modem to the DSLAM port and check that it reaches synchronisation within 90 seconds.
3. If synchronisation is attained, check that the modem stays in synchronisation for a minimum of 120 seconds.
4. Check via the element manager that aggregate downstream and upstream bandwidth achievable on the CPE modem is greater than 800 Mbit/s.

Expected Outcome – This test will be deemed a "Pass" if the modem attains synchronisation within 90 seconds, stays trained up for a minimum of 120 seconds and an aggregate rate of at least 800 Mbit/s can be confirmed, else the test will be deemed a "Fail". This test also verifies that the physical layer interface on the CPE modem is wired correctly (Requirement R.PHY.1).

B.4.2.3 Ethernet Layer

B.4.2.3.1. Ethernet Frame Size (R.ETH.1)

Using a traffic generator, transmit Ethernet frames at a continuous rate in the upstream and downstream directions. Confirm that the modem successfully forwards traffic with frame sizes in the range 68 – 1522 bytes with respect to the modem WAN interface, and between 1522 – 1534 bytes if supported by the CPE.

It should be noted that the frame size at the WAN interface includes the mandatory C VLAN tag which means the frame size as measured at the LAN interface may be 4 bytes shorter.

It is recommended that the maximum throughput is measured for a range of frame sizes between 68 – 1522 bytes (and beyond to 1534 bytes if supported) to uncover any frame processing issues or limitations which may impact the user experience.

B.4.2.4 WAN Layer

B.4.2.4.1. Support of IEEE 802.1q VLAN Encapsulation (R.WAN.1)

Support for VLAN encapsulation at the modem WAN port is implicitly covered by B.4.2.4.2.

B.4.2.4.2. Ingress traffic encapsulated within an IEEE 802.1q C-VLAN (R.WAN.2)

Confirmation that traffic from the modem is encapsulated in a VLAN on ingress to the Openreach DSLAM is implicitly covered by B.4.3.1.

B.4.2.4.3. Support of Multicast and Unicast over the same VLAN (R.WAN.3)

Implicitly covered by B.4.2.3.1 for GEA Data and downstream multicast, and B.4.2.4.7 for upstream multicast.

B.4.2.4.4. Ethertype (Tag Protocol Identifier) field of the Ethernet frame set to 0x8100 (R.WAN.4)

Withdrawn – covered by vendor self-certification.

B.4.2.4.5. CVLAN Canonical Format Indicator set to zero (R.WAN.5)

Withdrawn – covered by vendor self-certification.

B.4.2.4.6. VLAN ID set to 101 for when GEA Data and Multicast are used (R.WAN.6)

Withdrawn – covered by vendor self-certification.

B.4.2.4.7. IGMP reports encoded correctly (R.WAN.7)

Vendor to confirm (in writing) via the Modem Conformance Test Request form that if multicast is to be used, IGMP reports destined for Openreach Multicast for GEA employ IGMPv3 or IGMPv2 over C-VLAN ID 101, and that the Source Specific Multicast option within IGMPv3 is not used.

B.4.2.4.8. Multicast for GEA frames not encapsulated with PPP (R.WAN.8)

Vendor to confirm (in writing) via the Modem Conformance Test Request form that if multicast is to be used, the modem shall be able to forward IGMP packets as IPoE without any PPP encapsulation.

B.4.2.5 OAM Layer

B.4.2.5.1. Support of "dying gasp" (R.OAM.1)

a) Ensure a last gasp indication is received

B.4.2.5.2. Support of EFM OAM passive mode (R.OAM.2)

a) Verify that the EFMOAM session is established soon after the G.fast line reaches ShowTime without any configuration being required on the modem, and that the EFMOAM status is reported as Passive

b) Verify that it is not possible to change the EFMOAM status to Active via e.g. modem LAN side GUI interface

B.4.2.5.3. Support of EFM OAM loopback (R.OAM.3)

a) Confirm that the EFMOAM details of the modem have been successfully exchanged with the DSLAM and that Loopback has been reported as a supported capability by the modem.
b) Issue a command from the DSLAM to the modem for it to enable its loopback, and confirm that the modem's EFMOAM status changes accordingly.
c) Issue a command from the DSLAM to the modem for it to disable its loopback, and confirm that the modem's EFMOAM status changes accordingly

B.4.2.5.4. EFM OAM loopback

a) Confirm that the EFMOAM details of the modem have been successfully exchanged with the DSLAM and that Loopback has been reported as a supported capability by the modem.
b) Transmit Layer 2 test traffic simultaneously in the upstream and downstream directions as the full product rate, and confirm that there is no traffic loss and that the EFMOAM session remains up and stable
c) Issue a command from the DSLAM to the modem for it to enable its loopback with a defined timeout period, and confirm that the downstream traffic is returned upstream (albeit constrained to the upstream VDSL2 rate) and that upstream test traffic is blocked. This may be confirmed by inspecting the MAC addresses of the looped traffic.
d) Confirm that the loopback is removed by the modem as the timeout expires, and that the upstream and downstream traffic is re-established.

Note 1: Where PPP is used the PPP session may time out and go down

Note 2: If the modem is unable to maintain the EFMOAM session or the loopback during full test traffic load, it is advisable to repeat the test at lower traffic loads to establish the performance limitations of the modem

B.4.2.5.5. EFM OAM statistics collection (R.OAM.6, R.OAM.7 and R.OAM.7)

a) With the modem trained up and the EFMOAM session established, enable an EFMOAM loopback and verify the test traffic is returned upstream by the modem (see B.4.2.5.4)
b) Transmit a known amount of unicast Ethernet test downstream from the DSLAM towards the modem at a defined continuous rate (e.g. 100,000 frames at 80Mbps)
c) Repeat the previous step with broadcast and then multicast addressed test traffic
d) Issue a command from the DSLAM to retrieve all the statistics in from the modem. The modem shall return all the requested statistics, and their values should reflect the amount of test traffic transmitted

B.4.2.5.6. Y.1731 Service Layer OAM (R.OAM.8)

a) On the L2S create a Maintenance Association (MA) at Maintenance Domain (MD) level 1
b) Create a Maintenance End Point (MEP) within the MA on the connection (S and/or C VLAN) bound for the modem
c) Initiate a loopback test towards the modem
d) Verify that the modem replies to each LBM that is transmitted. Note any frame loss

It is recommended that the test above is repeated with bidirectional continuous test traffic in the background to verify that the modem is capable of detecting and responding to LBMs from the network even when forwarding user traffic.

B.4.3 CPE Filters

B.4.3.1.1. Compliance to ETSI TS 101 952 Part 1 (extended to 212 MHz) (R.FILTER.1)

B.4.3.1.2. Compliance to ETSI TS 101 952 Part 3 (extended to 212 MHz) (R.FILTER.2)

<END>